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(NASA-CR-157946) PRELIMINARY BENEFITS STUDY
FOR A PUBLIC SERVICE COMMUNICATIONS
SATELLITE SYSTEM: TASK ORDER 2 Final
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PRELIMINARY BENEFITS STUDY
FOR A PUBLIC SERVICE
COMMUNICATIONS SATELLITE SYSTEM

TASK ORDER II

FINAL REPORT

NOTE OF TRANSMITTAL

This preliminary study of the benefits of a Public Service Communication Satellite (PSCS) System was performed for the Office of Applications, National Aeronautics and Space Administration as Task Order II, Contract NASW-3047. The objective of this study was to provide preliminary estimates, by application, of the economic and social benefits which could result from an operational PSCS System. It is anticipated that these preliminary benefit estimates will be used by NASA to assist in the selection of those applications of the PSCS System that will be the subject of more detailed case studies.

The reader should note that it was not possible to examine all of the potential uses of a PSCS System in the study. The applications studied were selected on the basis of the expected availability of information to support the study, the anticipated importance of the application, and after consultation with the NASA/PSCS team.

There are many other potential uses of an operational PSCS System. While an attempt was made to use experience and judgement to preselect the more important uses, the fact that an application was not studied does not imply that its economic or social benefits are less significant than those that were studied.

The work described in this report was reviewed in two meetings with the NASA/PSCS team on 3 August 1977 and 17 November 1977. Several sections of this report have been expanded or clarified on the basis of comments received during these reviews.

The study was performed at ECON, Inc. by a team consisting of Mr. Philip Abram, Mr. Edward Gallagher, Mr. Joel Greenberg, Mr. Kenneth Hicks, Ms. Larrain Luckl, Mr. B. P. Miller, and Mr. Peter Stevenson.

Many individuals from academic institutions, government and industry assisted the study team in their efforts to estimate benefits of the applications of a PSCS System. While the list is too numerous to mention each individual's contributions, I do wish to express thanks to Mr. Samuel Hubbard of NASA Headquarters and Mr. Ahmed Meer of NASA Goddard Space Flight Center for their assistance and guidance in this study.

B. P. Miller
Vice President

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1. INTRODUCTION AND OVERVIEW OF RESULTS

OBJECTIVE

The objective of this preliminary benefit study is to provide estimates, by application, of the economic and social benefits which could result from an operational PSCS system. These preliminary benefit estimates could then be used by NASA to assist in the selection of those applications of an operational PSCS system that will be the subject of more detailed case studies. For this reason, the preliminary benefit study can be viewed as an effort to examine a broad range of potential applications in order to obtain first-order estimates of the potential benefits in each of these applications, without the expenditure of the resources needed if more detailed studies were to be conducted of each of these applications. Thus, this study is the first step in a screening process to select those applications that are the most significant when viewed from the economic and social viewpoints.

OBJECTIVE

- PROVIDE QUANTITATIVE ESTIMATES OF THE ECONOMIC AND SOCIAL BENEFITS OF A BROAD RANGE OF POTENTIAL PSGS APPLICATIONS

DEFINITION OF ECONOMIC AND SOCIAL BENEFITS

Two classes of benefits must be considered when the benefits of a proposed new technical capability for space communications are to be evaluated. For the purpose of this study, these two classes of benefits are considered to be the economic benefits and the social benefits. The economic or direct benefits are defined as those benefits that occur in the private and public sectors that result from the changes in the cost of the delivery of the service or the information by the new technical capability as compared to the cost of delivery by existing capabilities. Social or indirect benefits are defined as those benefits that result from increases in productivity or decreases in mortality or morbidity brought about by the introduction of the new technical capability. For example, a telemedicine application could produce economic benefits by reducing the cost of certain medical services. In addition, the same telemedicine application could also produce social benefits by reducing morbidity or mortality in the patient population served.

The purpose of these preliminary benefit studies is to provide quantitative estimates of these two benefit components in a broad range of potential PSCS applications.

DEFINITION OF ECONOMIC AND SOCIAL BENEFITS

- TWO BENEFIT COMPONENTS
 - + ECONOMIC - COST OF SERVICE
 - + SOCIAL - DECREASED MORTALITY AND/OR INCREASED PRODUCTIVITY

- PURPOSE OF BENEFIT EVALUATION IS TO CONVERT ABOVE TO SCALAR QUANTITIES
 - + DOLLARS
 - + YEARS

SCHEDULE

The schedule for the preliminary benefit studies is shown on the opposite chart. The requirement for these studies were defined in the Plan for the Economic Evaluation of the Public Service Communication Satellite System, and these studies correspond to Task 1.1 of this plan.¹ The list of potential uses of a PSCS exceeds the nine applications considered in these preliminary benefit studies. However, because of time and resource limitations, it was necessary to limit the applications to be studied to those shown. The nine applications studied were selected by ECON and NASA. Two criteria were used for the selection of these nine applications, namely, the availability of data to support the study and the expected benefits. An active user community exists for these and other potential PSCS applications, and it is entirely possible that some of the other applications not considered in these preliminary benefit studies could be as important as the nine applications considered in this study.²

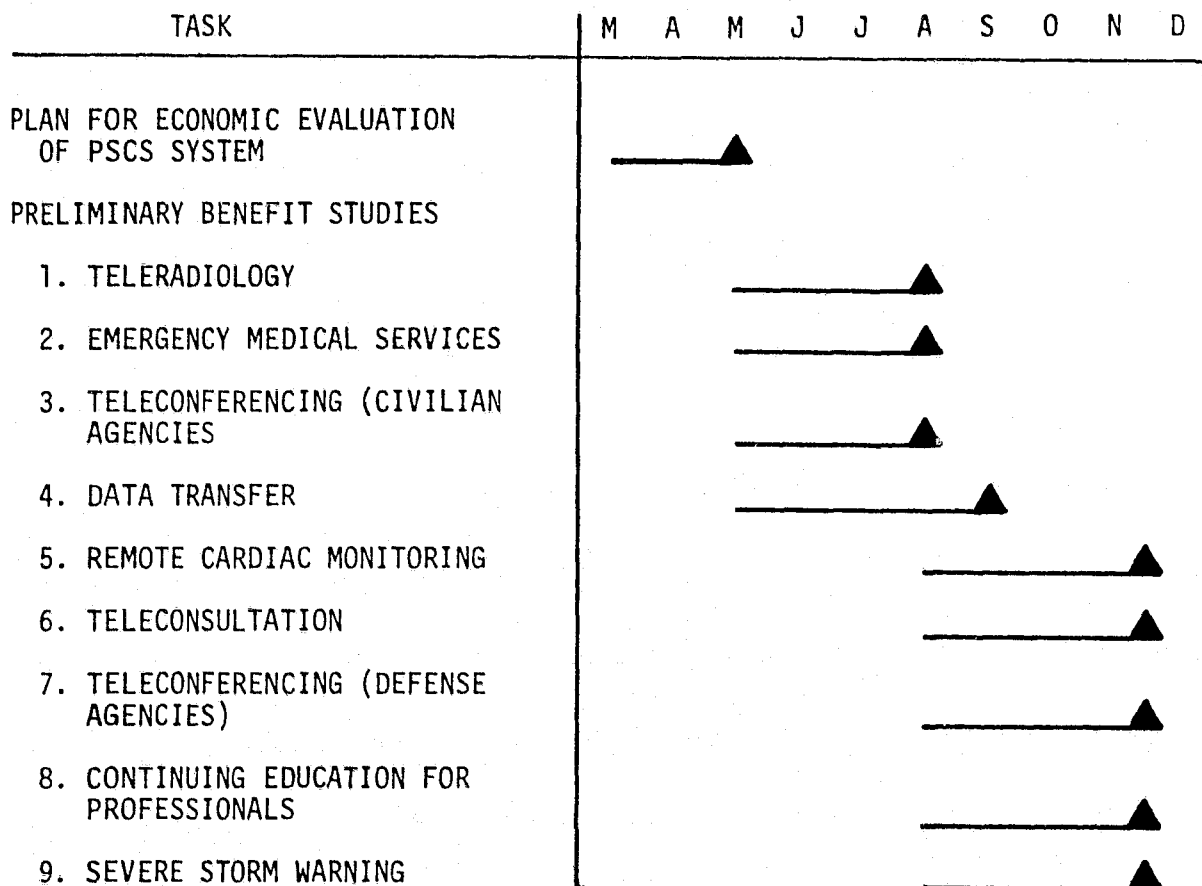
The level of effort applied in these preliminary benefit studies ranged from approximately one person-month for the severe storm warning study to about two person-months for each of the teleconferencing and telemedicine studies.

¹The Plan for the Economic Evaluation of the Public Service Communications Satellite System, ECON, Inc., May 2, 1977, Contract NASW-3047.

²Public Service Communications Satellite System Review and Experiment Definition Workshop, Draft Report, March 29, 1977, NASA-Goddard Space Flight Center.

SCHEDULE

CALENDAR YEAR 1977



LEGEND = COMPLETED

NOT COMPLETED

LIMITATIONS OF PRELIMINARY BENEFIT STUDIES

The reader of this report should recognize that there are certain limitations to these preliminary benefit studies. These limitations result from the practical considerations of the time and resources available for these studies, and the small samples of data available on the applications studied. It is believed that these limitations do not affect the adequacy of these studies to provide a basis for the selection of applications for detailed case studies, and that most of these limitations can be alleviated in the case studies.

LIMITATIONS OF PRELIMINARY BENEFIT STUDIES

- BENEFITS ARE THOSE OF IMPROVED COMMUNICATIONS
- MANY COSTS NOT WELL DEFINED
- BENEFITS ASSUME STEADY-STATE OPERATIONS (FOR EXAMPLE, START-UP COSTS NOT CONSIDERED)
- REACTION OF COMPETITION NOT CONSIDERED
- DID NOT SPEND MUCH TIME ON INSTITUTIONAL AND POLITICAL PROBLEMS

OVERVIEW OF RESULTS

An overview of the results of the preliminary benefit studies is shown on the opposite chart. For each PSCS application considered in this study, an estimate of the annual benefit and the identification of the types of benefits found in the study is shown. Also shown are subjective estimates of two additional factors that are important in the selection of case studies. The "Capturability of Benefits by Others" estimates the possibility of existing carriers moving into the anticipated market in advance of an operational PSCS, while the "Estimated Availability of Data for Case Study" indicates an assessment of the data needed to support a case study in the subject application.

On the basis of these estimates, it is believed that the most productive areas for case studies are telemedicine applications, teleconferencing and continuing education for professionals.

SUMMARY OF PRELIMINARY BENEFITS

| <u>APPLICATION</u> | <u>BENEFIT TYPE</u> | <u>MAGNITUDE OF ANNUAL BENEFIT</u> | <u>CAPTURABILITY OF BENEFITS BY OTHERS</u> | <u>ESTIMATED AVAILABILITY OF DATA FOR CASE STUDY</u> |
|--|---|---|--|--|
| HEALTH SERVICES: | | | | |
| ● EMERGENCY MEDICAL SERVICES | SOCIAL (LIVES SAVED) | \$110-250M (5600-12300 LIVES) | LOW | HIGH |
| ● TELERADIOLOGY | RADIOLOGIST PRODUCTIVITY TRAVEL COST SAVINGS REDUCED HOSP. PAYMENTS REDUCED LOST WAGES | \$5 - 11M \$0 - 1M \$20 - 46M \$14 - 31M | LOW | HIGH |
| ● REMOTE CARDIAC MONITORING | COST SAVINGS | \$1M | LOW | HIGH |
| ● TELECONSULTATION | SOCIAL (MORTALITY RATE REDUCTION) | NEEDS FURTHER STUDY | LOW | MEDIUM |
| DATA TRANSFER: | | | | |
| ● NATIONAL NETWORK CONNECTIVITY | COST SAVINGS | \$18 - 190M | MEDIUM-HIGH | MEDIUM |
| ● NATIONAL COMPUTER BASED EDUC. | COST SAVINGS | \$11-2930M | LOW-MEDIUM | LOW |
| ● HIGH SCHOOL DROPOUT PREVENTION | SOCIAL | \$10 - 950M | LOW | LOW |
| ● ADULT EDUCATION | SOCIAL | \$ 0 - 9M | LOW | LOW |
| ● PRISON POPULATION EDUCATION | SOCIAL | \$ 0 - 3M | LOW | LOW |
| ● MEDICAL HISTORY RECONSTRUCTION | COST SAVINGS | \$10 -144M | LOW | HIGH |
| CONTINUING EDUCATION FOR PROFESSIONALS (LEGAL) | COST SAVINGS | \$17M | MEDIUM | MEDIUM |
| TELECONFERENCING | COST SAVINGS + PRODUCTIVITY | \$180M | HIGH | MEDIUM |
| SEVERE STORM WARNING | COST SAVINGS SOCIAL (LIVES SAVED) | \$18 - 48M (78 - 203 LIVES) | MEDIUM | HIGH |

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2. RESULTS OF PRELIMINARY BENEFIT STUDIES

2.1 MEDICAL APPLICATIONS

2.1.1 TELERADIOLOGY

RATIONALE FOR SATELLITE TRANSMISSION OF RADIOLOGIC IMAGES

Teleradiology is defined as the use of narrow band communications for the facsimile transmission of static X-rays, and the use of video bandwidth communications for the transmission of real-time fluoroscopic imagery. X-ray and fluoroscopic images would be transmitted from outlying rural hospitals to a major medical center. This use of communications could increase radiologist productivity, and reduce the time needed for radiologic analysis of patients in rural hospitals.

The American College of Radiology manpower report notes that "there appears to be a geographic imbalance in the distribution of radiologists and presumably in the availability of their services."¹ The imbalance favors certain states in the southwest and northeast regions at the expense of rural states in the southeast and mountain west. Though the national radiologist-to-population ratio is 1:17,360, states such as Mississippi or Montana have ratios of 1:40,000.

The severity of the shortage in rural areas is probably worse than the ratios indicate. First of all, it is not clear that even the national average ratio represents a sufficient supply. Secondly, the radiologist-to-population ratio gives no indication of the radiologist distribution within the state. A radiologist traveling 2 to 3 hours a day to rural hospitals is much less effective than his counterpart in an urban area where patients can easily visit the hospital or office. In the course of this preliminary benefit study we were unable to locate information on the distribution of radiologists in rural areas. Perhaps the only way the distribution could be ascertained is by tediously deriving summary statistics from the American College of Radiology Directory. This publication lists all members of the college (almost all practicing radiologists in the United States) with their addresses.

¹Report of the ACR Task Force on Manpower and Facilities, (Chevy Chase, Maryland: American College of Radiology, 1972), p. 8.

RATIONALE FOR SATELLITE TRANSMISSION OF RADIOLOGIC IMAGES

IN MANY RURAL AREAS THERE EXISTS AN ACUTE SHORTAGE OF RADIOLOGISTS.

- THOUGH THE NATIONAL AVERAGE RATIO OF PATIENT-CARE RADIOLOGISTS TO POPULATION IS 17,000 TO 1, THE AVERAGE RATIO IN MANY RURAL AREAS IS 40,000 TO 1.
- AS A RESULT, RURAL RADIOLOGISTS SPEND SEVERAL HOURS A DAY TRAVELING AMONG THE SEVERAL HOSPITALS OF THEIR DISTRICT.
- PATIENTS, SURGEONS, AND OTHER PHYSICIANS OFTEN WAIT A DAY OR MORE AWAITING PROPER DIAGNOSIS.

POTENTIAL TELERADIOLOGY APPLICATIONS

There are three potential radiologic applications for a public service communications satellite. The technology for transmission of static X-ray imagery over conventional ground lines appears to be at hand. The Cooley Prototype Service Inc. plans to market a facsimile device with 2.5-minute to 3.0-minute transmission time per image.¹ Since it was not clear whether this imagery was of sufficient resolution to aid in diagnosis, an image provided by the Alaska Area Native Health Service was shown to Dr. Hale of the Hattiesburg, Mississippi radiology group. The particular image provided to Dr. Hale was produced on the Cooley facsimile device at the corporate headquarters in Colorado. He felt that the quality of the image was sufficient for accurate diagnosis of both bone fractures and important internal organs. Since the transmission of static images requires narrow band technology, it is not yet clear whether satellite-aided transmission would be needed. One would have to make a cost-effectiveness comparison between satellite and ground lines before the social benefits in radiology could be claimed.

The technology required for transmission of fluoroscopies or dynamic X-rays is not yet apparent. Some have spoken of using a video camera pointed at the fluoroscope but the question of sufficient resolution still remains. Importantly, though, if transmission is possible, this innovation should quickly free the rural radiologists from extensive travel. It appears that, in many rural areas, the main reason for frequent radiologist travel is to perform fluoroscopies.

Transmission of computer axial tomographic (CAT) imagery by any means appears to be quite far in the future. If it does come about, it would be possible to separate the sensing and processing modules of the device such that the major medical center would be equipped with one processing unit to serve a large geographic area. Since the processing units cost approximately \$600,000 apiece, rural areas could realize substantial savings with CAT centralization. Since the concept of satellite transmission of CAT imagery is presently only an idea, the cost savings that could exist here have not been studied.

¹Appendix A. Facsimile Transmission of X-Ray Imagery.

POTENTIAL TELERADIOLOGY APPLICATIONS

THERE ARE THREE RADIOLOGIC APPLICATIONS FOR PSCS:

1. TRANSMISSION OF STATIC X-RAY IMAGERY
 - THOUGH THERE ARE COURIER SYSTEMS IN RURAL AREAS, THE TURN-AROUND TIME BETWEEN SENDING X-RAY AND RECEIPT OF DIAGNOSIS RANGES FROM ONE DAY TO ONE WEEK.
2. TRANSMISSION OF FLUOROSCOPIC IMAGERY
 - FLUOROSCOPIES ARE REAL-TIME EXAMINATIONS THAT UNDER PRESENT TECHNOLOGY REQUIRE PRESENCE OF RADIOLOGIST.
 - SHORTAGE OF RURAL RADIOLOGISTS REQUIRES EXTENSIVE TRAVEL TO PERFORM THESE EXAMINATIONS.
3. TRANSMISSION OF COMPUTER AXIAL TOMOGRAPHIC (CAT) IMAGERY
 - COST AND LACK OF PATIENT VOLUME PRECLUDES PURCHASE OF CAT SCANNERS BY RURAL HOSPITALS.
 - IT IS POSSIBLE TO SEPARATE THE SENSING AND PROCESSING MODULES OF THE DEVICE.

ONLY THE BENEFITS OF STATIC X-RAY AND FLUOROSCOPY TRANSMISSIONS WILL BE COVERED IN THIS REPORT.

ESTIMATION OF TELERADIOLOGY BENEFITS: MISSISSIPPI STUDY

In order to estimate the benefits of teleradiology for the entire United States, a specific geographic area was selected for close examination in the hope that the results there could be generalized. Since the technology being evaluated is quite new, it was believed that an understanding of current radiologic logistics in a rural area was essential. The area chosen was a section of southeastern Mississippi served by a major medical center located in Hattiesburg, Mississippi. The population in this area is approximately 200,000 people and is served by five radiologists. It was determined that two particular facets of radiologic health care could be impacted by an operational teleradiology system that was capable of static X-ray and fluoroscopic transmission. These are: (1) radiologist productivity and (2) average length of patient stay in hospital.

The Hattiesburg radiology group has five members, three of whom are lower paid junior partners. The junior partners are MDs, trained as radiologists. Three times a week a junior member of the group travels 120 miles round trip to Tylerstown, Mississippi, in order to perform fluoroscopies and examine static X-rays. If the radiologist were able to receive the fluoroscopic imagery remotely in Hattiesburg he would save: (1) the two hours of driving time; (2) the time spent interpreting the static X-rays, since they could be sent by courier¹ or transmitted to Hattiesburg; and (3) other organizational inefficiencies associated with the smaller rural hospital. In fact, the comptroller of the Hattiesburg radiology group² felt that what was accomplished now in six hours to support the Tylerstown effort for one day could be done within one hour in Hattiesburg. Therefore, if three days out of five represents 60 percent of one full-time radiologist, and if five-sixths of this time could be saved using remote interpretation of fluoroscopies, then fully 50 percent of one junior radiologist's time could be saved each year. Placing a dollar value on the increase in productivity in general is a difficult task since several assumptions on what a junior radiologist would do with the added time are needed.

It is probably safe to assume that the added time would be spent caring for more patients and that the charge per patient or X-ray would remain at the same real rate. If the increase in the radiologist's annual salary is a measure of the social benefits of providing better health services than previously, then the benefits are roughly \$45,000 a year to southeastern Mississippi, excluding transportation cost savings.

¹ It must be understood that the static images are interpreted in Tylerstown since the radiologist apparently has plenty of time between fluoroscopies, his primary purpose in being there. If he did not make the visit then the static X-rays transmitted would be sent by courier under the current system of transmitted if the facsimile devices were in place.

² Compiled from notes on meeting with Mr. Jim Sumerall, Administrator of the Hattiesburg Radiology Group, 2625 Lincoln Road, Hattiesburg, Mississippi, 39401.

ESTIMATION OF TELERADIOLOGY BENEFITS: MISSISSIPPI STUDY

RADIOLOGY IN SOUTHEASTERN MISSISSIPPI:

BENEFITS DUE TO INCREASING PRODUCTIVITY OF RADIOLOGIST:

- FIVE RADIOLOGISTS SERVE POPULATION OF 200,000.
- THREE TIMES A WEEK A JUNIOR MEMBER OF THE RADIOLOGY GROUP TRAVELS 60 MILES ONE WAY TO TYLERSTOWN TO INTERPRET STATIC X-RAY PICTURES AND FLUOROSCOPIES.
- THIS EFFORT IS EQUIVALENT TO 60% OF ONE FULL-TIME RADIOLOGIST.
- BECAUSE OF TRAVEL TIME AND OTHER INEFFICIENCIES, WHAT IS DONE IN 6 HOURS AT TYLERSTOWN COULD BE ACCOMPLISHED IN 1 HOUR AT THE HATTIESBURG MEDICAL CENTER.
- THEREFORE, TRANSMISSION OF BOTH STATIC AND FLUOROSCOPIC IMAGES FROM TYLERSTOWN TO HATTIESBURG WOULD ALLOW AN EQUIVALENT TIME SAVINGS OF 50% OF ONE FULL-TIME RADIOLOGIST.
- A VERY CONSERVATIVE ESTIMATE OF A RADIOLOGIST'S SALARY IN HATTIESBURG IS \$90,000 A YEAR, IMPLYING A BENEFIT OF \$45,000.

BENEFITS OF REDUCING PATIENT'S TIME IN HOSPITAL

Southeastern Mississippi has an extensive courier system for sending static X-rays between the several rural hospitals and the major medical center located in Hattiesburg. The minimum turn-around time of one day between sending the images and receipt of diagnosis often adds one more day to a patient's average length of stay. Surgeons wait for radiology diagnosis before they operate, while physicians wait for diagnosis before setting severe fractures. The average daily patient stay statistics compiled by the American Hospital Association for each region of the country imply that the average stay in Mississippi hospitals is one to two days longer than the national average.¹

Assuming that an operating system of static X-ray transmission via facsimile device could cut the turn-around time between sending and receipt of diagnosis to less than a few hours, the benefit would be a \$100 per patient day saved. This figure was estimated by simply adding the daily average service charge per patient² and the median daily income per patient. The daily average service charge was used since it is not known how many of the patients using the courier system today are in intensive care, requiring specialists or other medical services which would cost much more. All patients pay a service charge, so this figure was used as a conservative estimate. A patient who must stay at the hospital one more day than necessary also loses one day's income. For, if the "at home" recuperation time after release is constant, then the patient's return to work is delayed by one day. The volume of static X-rays sent via the courier system in southeastern Mississippi implies that there are 60 patients a week who are staying one day longer than necessary. Sixty patients a week at \$100 a day for a year implies a benefit of \$312,000 annually for southeastern Mississippi.

¹Survey of Charges in Community Hospital as of January 1, 1975,
(American Hospital Association, 1975), p. 175.

²Ibid.

BENEFITS OF REDUCING PATIENT'S TIME IN HOSPITAL

- THE MINIMUM TURN-AROUND TIME OF ONE DAY BETWEEN SENDING STATIC IMAGES AND RECEIPT OF DIAGNOSIS OFTEN ADDS ONE MORE DAY TO PATIENT'S AVERAGE STAY.
- TAKING INTO ACCOUNT THE AVERAGE DAILY SERVICE CHARGE FOR HOSPITALS AND VALUE OF ONE DAY'S INCOME IMPLIES A POTENTIAL SAVINGS OF \$100 A DAY PER PATIENT.
- CONSEQUENTLY, IF 60 PATIENTS A WEEK COULD EACH SAVE ONE DAY IN THE HOSPITAL, THE SAVINGS DUE TO TELERADIOLOGY IN SOUTHEASTERN MISSISSIPPI WOULD BE \$312,000 A YEAR.

TELERADIOLOGY IN SOUTHEASTERN MISSISSIPPI: SUMMARY OF REGIONAL BENEFITS

In summary, the annual teleradiology benefits for southeastern Mississippi are estimated to be \$357,800 in undiscounted 1977 dollars. The travel cost savings, estimated at \$2,800 annually, was computed by assuming that with teleradiology the 18,720 miles (at \$0.15/mile) driven each year by junior radiologists will not be necessary.

TELERADIOLOGY IN SOUTHEASTERN MISSISSIPPI: SUMMARY OF REGIONAL BENEFITS

| | |
|--|----------------|
| INCREASE IN RADIOLOGIST PRODUCTIVITY | \$ 45,000 |
| TRAVEL COST SAVINGS | 2,800 |
| REDUCTION IN PATIENT HOSPITAL STAY | <u>312,000</u> |
| ANNUAL TELERADIOLOGY BENEFIT (1977 DOLLARS, UNDISCOUNTED) | \$359,800 |

GENERALIZATION OF MISSISSIPPI TELERADIOLOGY BENEFITS

Generalization of benefits derived by the consumers' surplus technique requires that careful attention be paid to both the demand and supply side of the market. The market in this case is for radiologic health care service. On the demand side it appears that the only problems inherent in the generalization lie with race and average income. A comparison of Mississippi and all U.S. rural demographic statistics shows that whereas only 9 percent of the rural U.S. population are black, whereas fully 26 percent of the seven-county case study population in rural southeastern Mississippi are black. It is also clear that the median income for a family of four in Mississippi is about \$1,000 less than that for all U.S. rural families. Fortunately for the generalization, it would appear that these factors should not radically alter the demand for radiologic services. There is no reason to suspect that blacks demand more or less X-ray services than whites nor is there any reason to believe that, given the availability of X-ray services in a rural area, income would play a significant role. Most studies have shown that the demand for health care in general is income inelastic,¹ given the existence of medical insurance programs and Medicaid. The demand for health care is a function of education and perhaps another study could address this problem.

The substantive factors affecting the generalization are on the supply side. Though the number of radiologists is known by state, an extensive review of health statistics has found no compilation on the availability of radiologists in rural areas. Further study in this area should explore the number of radiologists in those areas outside the standard metropolitan statistical reporting areas (SMSA).

Another problem faced on the supply side is the lack of information on the distribution of radiologists within the states. Even if the state information were available for outside the SMSAs, knowledge of the distances traveled by radiologists would be essential to an accurate generalization. Finally, the extent of courier systems is important to the generalization since the benefits will be larger or smaller depending on whether the Mississippi courier system is slower or faster than those found in other rural areas.

¹Michael Grossman, Demand for Health: Theoretical and Empirical Investigation, (New York: NBER, 1972).

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GENERALIZATION OF MISSISSIPPI TELERADIOLOGY BENEFITS

- COMPARISON OF MISSISSIPPI AND ALL U.S. RURAL DEMOGRAPHIC STATISTICS SHOWS THAT THE ONLY SIGNIFICANT DIFFERENCES ARE IN RACE AND AVERAGE INCOME.
- IT WOULD SEEM THAT THESE FACTORS DO NOT RADICALLY AFFECT DEMAND FOR RADIOLOGIC SERVICES.
- THE SUBSTANTIVE FACTORS AFFECTING THE GENERALIZATION ARE ON THE SUPPLY SIDE:
 - NUMBER OF RADIOLOGISTS
 - DISTANCES TRAVELED (DISTRIBUTION OF X-RAY FACILITIES)
 - EXISTENCE OF COURIER SYSTEMS.

DISTRIBUTION OF RADIOLOGISTS BY STATE

The map of the United States shows the general distribution of radiologists by states.¹ Those states outlined (Indiana, Iowa, Mississippi, South Carolina and South Dakota) represent the five worst states, or the lowest 10 percent, whereas those states with the cross-hatch shading are among the best. The 1.15 distribution index refers to the following ratio:

$$\text{dist. index} = \frac{\% \text{ of radiologists in United States found in state}}{\% \text{ of U.S. population in state}}$$

Therefore if the national average represents an acceptable level of radiologic health care services, then a state with a distribution index greater than 1.00 is above average.




Unfortunately, statistics on the numbers of radiologists tell us little about the real distribution in rural areas. Though Mississippi is ranked in the bottom 10 percent, it is very possible that a larger state such as Montana may have a poorer level of radiologic services because of longer travel distances. For example, in Mississippi the patient might travel 40 miles for a visit, while in Montana the distances might be 150 miles.

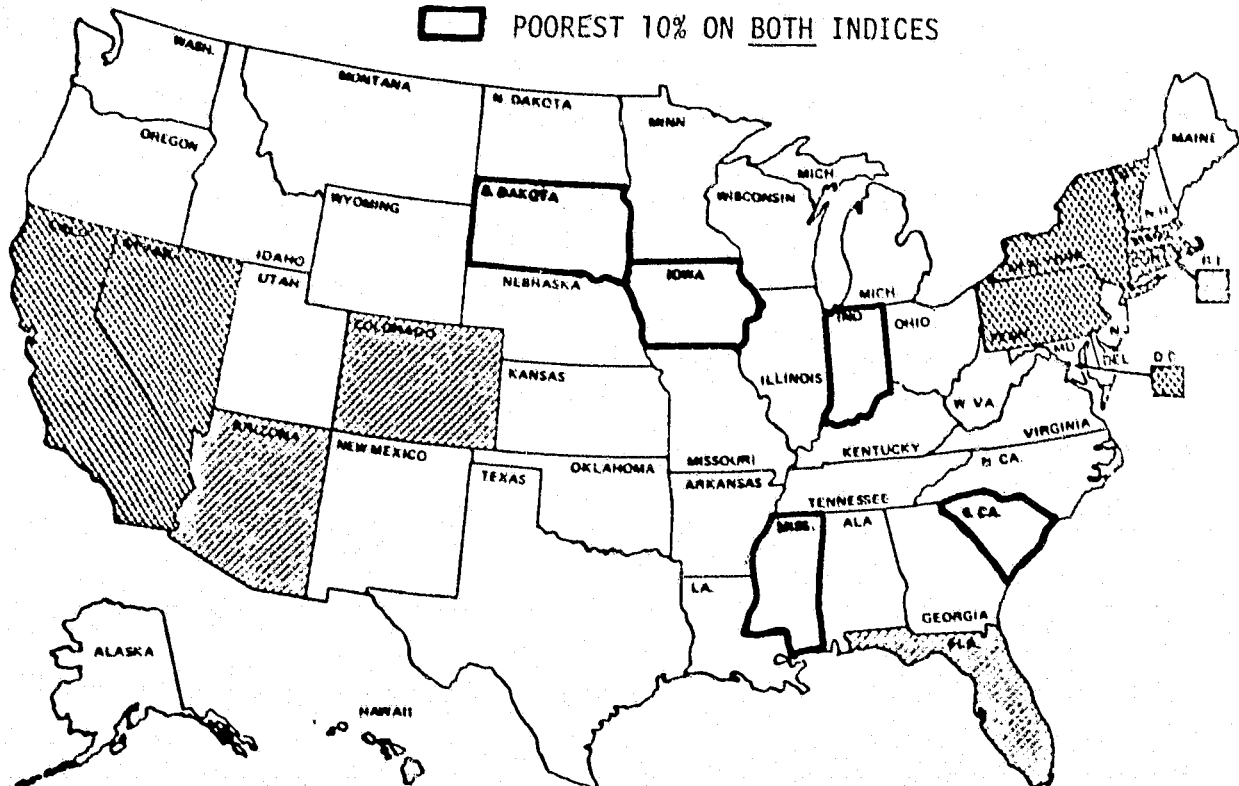
¹American College of Radiology Manpower Report, 1972.
(Most recent issue available.)

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DISTRIBUTION OF RADIOLOGISTS BY STATE

MOST AND LEAST FAVORED STATES

-  LESS THAN 19,000 PER RADIOLOGIST
-  GREATER THAN 1.15 DISTRIBUTION INDEX
-  POOREST 10% ON BOTH INDICES



MAP 1*

* AMA DIST. OF PHYS. 1972

TELERADIOLOGY: CONCLUSION

In conclusion, though Mississippi is among the lowest 10 percent of all states with regard to number of radiologists, this fact could not be used in the generalization for two important reasons. First of all, the distribution of radiologists as a function of distance traveled is unknown and crucial to the generalization. Secondly, not enough is known about the number and distribution of radiologists in rural areas. Though a state like Alaska or Montana may be classified as entirely rural, many of the Deep South and rural Appalachian states have SMSAs within their borders which would perturb the limited statistics at hand. As a result, the best measure of rural America's population was used in the generalization as an upper bound and population of the "Thinly Populated States" (TPS) was used as a lower bound. A TPS is a state, as defined by the Bureau of Census, having a population density below a certain level. Therefore, the rural populations of California or New York would be omitted from this estimate. The annual dollar benefits shown are expressed in undiscounted 1977 dollars and range between \$39 million and \$88 million.

TELERADIOLOGY: CONCLUSION

- MISSISSIPPI IS RANKED IN THE BOTTOM 10% OF ALL STATES AS TO THE NUMBER OF RADIOLOGISTS. BUT QUALITY OF RADIOLOGY CARE IS DEPENDENT ON DISTANCE BETWEEN RADIOLOGIC FACILITIES AND THE EXISTENCE OF COURIER SYSTEMS.
- AS A RESULT, RADIOLOGIC SERVICES MIGHT BE WORSE IN MONTANA OR IDAHO, FOR EXAMPLE.
- THE MISSISSIPPI RESULTS WERE GENERALIZED TO THE ENTIRE RURAL POPULATION OF THE UNITED STATES (OUTSIDE SMSA) AND THEN SEPARATELY TO THE POPULATION OF THINLY POPULATED STATES (TPS) OUTSIDE SMSAs.

| | | |
|---------------------|--|---|
| <u>UPPER BOUND:</u> | ENTIRE RURAL POPULATION BENEFIT = \$88 MILLION | } ANNUAL BENEFIT IN 1977 DOLLARS |
| <u>LOWER BOUND:</u> | TPS RURAL POPULATION = \$39 MILLION | |

2.1.2 EMERGENCY MEDICAL SERVICES

BENEFITS OF SATELLITE-AIDED EMERGENCY MEDICAL SYSTEMS (EMS)

Satellite-aided Emergency Medical Systems (EMS) is defined as the use of satellite communication between a fixed-base hospital and mobile emergency units for the transmission of biomedical telemetry. The biomedical telemetry is transmitted by paramedics from the site of the incident or enroute to the hospital for interpretation by MDs at the hospital. The paramedics receive voice instructions from the MDs and can take life-savings actions.

Comprehensive biomedical telemetry coverage has considerable merit in rural areas. The mortality rate from accidents and heart attacks in these areas is three to four times that of urban areas because these events happen at greater distances from medical centers.¹ As a result, both the federal and state governments have encouraged regionalization of EMS by providing funding and passing legislation allowing paramedics in the field to administer comprehensive first aid under physician supervision. The transmission of biomedical telemetry with two-way communication to the hospital will continue to grow in urban areas but unfortunately will be restricted in rural areas unless some means is found to extend telemetry coverage economically. Given the cost of constructing and maintaining ground microwave towers, it appears that few rural communities can afford towers every 30 to 40 miles.

The need for satellite-aided EMS is clear in many rural ambulance districts which telemeter biomedical information from mobile ambulance units to the emergency room. Construction of microwave tower networks would probably be too expensive for many rural areas and as a result transmission via satellite is quite attractive from a cost-effective standpoint. In addition to this direct economic benefit, there is also a social (or indirect) benefit that could result from the reduction of morbidity and mortality (i.e., productive life extension) in rural areas.

¹ Cecil Burge, "Some Potential Applications of a Public Service Satellite in Health Care Delivery," paper presented at PSSC meetings, Session 36, New York, April 19-21, 1977.

BENEFITS OF SATELLITE-AIDED EMERGENCY MEDICAL SYSTEMS (EMS)

RATIONALE FOR APPLICATION:

- IN RURAL AMERICA IT IS NOT UNCOMMON FOR THE PATIENT/EMS SYSTEM ENCOUNTER TO OCCUR 60 TO 100 MILES FROM THE NEAREST DEFINITIVE HOSPITAL CARE.
- CONSEQUENTLY, COMPREHENSIVE BIOMEDICAL TELEMETRY COVERAGE APPEARS TO HAVE CONSIDERABLE MERIT FOR HEART ATTACK AND TRAUMA VICTIMS, WHO HAVE A MORTALITY RATE OF THREE TO FOUR TIMES THAT OF URBAN VICTIMS.
- GIVEN THE RECENT TREND TOWARD REGIONALIZATION OF EMS IN RURAL AREAS, AND USE OF EKG TELEMETRY, THE LIMITING FACTOR NOW APPEARS TO BE THE EXTENT OF TELEMETRY COVERAGE.
- IT SEEMS LIKELY THAT FEW RURAL COMMUNITIES COULD AFFORD TO CONSTRUCT AND OPERATE AN EXTENSIVE MICROWAVE TOWER RELAY SYSTEM.

EMS IN SOUTHEASTERN MISSISSIPPI

The geographical area chosen for study of this telemedicine application was the service area of the Southeastern Air Ambulance District (SEMAAD). SEMAAD is an interesting example of the trend toward regionalization in rural EMS and it covers its operating expenses entirely by local tax assessments. The SEMAAD district has been chosen for study since their personnel have already collected and compiled information on the economics of rural EMS. In fact, the SEMAAD staff has proposed to the Department of Transportation (DOT) that the federal government fund the capital costs of using NASA's ATS-3 in order to supplement their existing telemetry network. Presently their network covers a radius of only about 20 to 30 miles of the 4000-square-mile district. A study conducted by SEMAAD estimated that the capital cost of providing comprehensive telemetry in Mississippi using existing terrestrial technology was \$5.5 million. This was felt to be much too high and hence the request to DOT.

EMS IN SOUTHEASTERN MISSISSIPPI

- THE SOUTHEASTERN MISSISSIPPI AIR AMBULANCE DISTRICT (SEMAAD) IS AN INTEGRATED RURAL EMS SYSTEM SERVING ABOUT 180,000 PEOPLE, OVER A 4,000-SQUARE-MILE AREA OF SOUTHERN MISSISSIPPI.
- THERE IS ONLY ONE FULLY STAFFED EMERGENCY ROOM FOR THIS DISTRICT, LOCATED IN HATTIESBURG.
- THOUGH AT PRESENT SEMAAD HAS BIOMEDICAL TELEMETRY COVERAGE FOR 20 TO 30 MILES ON GOOD DAYS, SOME PATIENTS ARE AS FAR AS 100 MILES FROM HATTIESBURG.
- A STUDY CONDUCTED FOR SEMAAD ESTIMATED THAT THE COST OF PROVIDING COMPREHENSIVE TELEMETRY IN MISSISSIPPI, USING EXISTING TERRESTRIAL TECHNOLOGY, WAS \$5.5 MILLION.

BENEFITS OF SATELLITE-AIDED EMS IN SOUTHEASTERN MISSISSIPPI

The economic benefit to SEMAAD of satellite coverage will be the forecasted change in the mortality rate as a function of telemetry coverage. The mortality statistics of the current 20-mile coverage system will be compared with the no-telemetry system used previously to give an indication of this change in mortality. For this study only the mortality statistics on myocardial infarctions (MI) were available. The 150 deaths in the SEMAAD district last year due to MIs which were taken to the Hattiesburg Medical Center occurred even though 20-mile biomedical telemetry coverage was available. The statistic is misleading, though, since it is not known how many victims died in route to the hospital and how many were dead when the paramedics arrived. Under Mississippi law, and under the laws of almost all states, only a certified physician can sign a death certificate and legally declare the patient deceased. Therefore, even though the paramedics in many cases could do absolutely nothing, the patient had to be transported for legal purposes to the physicians in Hattiesburg.

Approximately 47 percent of the myocardial infarctions were due to arrhythmias (electrical failure). These patients can be saved if trained paramedics arrive in time with defibrillation equipment. Therefore, if 50 percent of the MIs were alive when paramedics arrived, and if 47 percent of these were arrhythmia victims, then comprehensive telemetry coverage could save 35 lives a year in SEMAAD alone.

BENEFITS OF SATELLITE-AIDED EMS IN SOUTHEASTERN MISSISSIPPI

- LAST YEAR THERE WERE 150 DEATHS DUE TO MYOCARDIAL INFARCTIONS IN THE HATTIESBURG EMERGENCY ROOM WHICH WERE TRANSPORTED BY SEMAAD. SEMAAD DID HAVE THE 20-MILE TELEMTRY COVERAGE FOR THIS YEAR.
- APPROXIMATELY 47% OF THE CARDIAC FATALITIES WERE DUE TO ARRHYTHMIAS (ELECTRICAL FAILURE). THESE PATIENTS CAN BE SAVED IF TRAINED PARAMEDICS WITH DEFIBRILLATION EQUIPMENT AND MONITORED BY PHYSICIANS ARRIVE IN TIME.
- IT IS NOT KNOWN HOW MANY OF THE 150 MORTALITIES DIED BEFORE PARAMEDICS ARRIVED, BUT 50% IS A VERY CONSERVATIVE FIGURE.
- CONSEQUENTLY, A CONSERVATIVE ESTIMATE OF 35 ARRHYTHMIAS VICTIMS PER YEAR SAVED BY COMPREHENSIVE EMS TELEMTRY WILL BE USED.

BASIS FOR ESTIMATION OF NATIONAL BENEFITS OF SATELLITE-AIDED EMS

The dollar value of saving a life is difficult to assess. One method often employed by economists is to estimate the present value of lifetime earnings of the individual at the age when the accident occurred. Unfortunately, for rural southeastern Mississippi the median age for heart attack and the life expectancy after a major heart event were not known. Using life-cycle tables as provided by the Rand Corporation,¹ it was conservatively estimated that the lifetime discounted earnings after a major heart event would amount to \$20,000. Therefore, the value of saving 35 victims a year would be equivalent to a savings of \$700,000 for the SEMAAD service area.

¹Measuring the Social Impact of Heart and Circulatory Disease Programs: Preliminary Framework and Estimates. Jan Paul Acton, Rand, R-1697-NHLI, April 1975.

BASIS FOR ESTIMATION OF NATIONAL BENEFITS OF SATELLITE-AIDED EMS

- SEMAAD IS PROBABLY ONE OF THE BEST EQUIPPED RURAL EMS SYSTEMS IN THE UNITED STATES. EXISTENCE OF AIR-AMBULANCE SERVICE TO THE ENTIRE 400-SQUARE-MILE AREA AND 20-MILE EKG TELEMETRY SYSTEM ARE EXAMPLES.
- AS A RESULT, THE SEMAAD MORTALITY RATE FOR ARRHYTHMIAS VICTIMS IS PROBABLY MUCH LESS THAN FOR THE REMAINDER OF RURAL AMERICA.
- IF 35 ARRHYTHMIAS VICTIMS ARE SAVED PER YEAR IN THE SEMAAD DISTRICT, THE BENEFIT WOULD BE \$700,000. A \$20,000 VALUE WAS GIVEN TO EACH LIFE--A VERY CONSERVATIVE FIGURE.
- IF THE SEMAAD RESULTS ARE GENERALIZED TO ALL RURAL AMERICA, THE NUMBER OF LIVES SAVED WOULD BE 12,250. IF THE RESULTS ARE GENERALIZED TO THE THINLY POPULATED STATES (TPS), THE LIVES SAVED WOULD BE 5,670.

NATIONAL BENEFITS OF SATELLITE-AIDED EMS FOR ARRHYTHMIA VICTIMS

Using the same methodology employed previously for the teleradiology study of generalizing the results to all of rural America as an upper bound, and the Thinly Populated States (TPS) as a lower bound, implies that 5,670 to 12,250 lives could be saved each year with comprehensive EKG telemetry for rural areas. Using the \$20,000 figure mentioned above implies an annual benefit of \$113 million to \$245 million undiscounted, in 1977 dollars.

A more detailed study of EMS should include consideration of the age and possible life extension for heart attack victims, and should also include victims of other trauma such as automobile accidents.

NATIONAL BENEFITS OF SATELLITE-AIDED EMS FOR ARRYTHMIA VICTIMS

- EVALUATING EACH LIFE SAVED AT \$20,000 IMPLIES:

| | | | |
|---|-----------------|---|---|
| BENEFIT OF SATELLITE-AIDED EMS FOR ALL RURAL AREAS | = \$245 MILLION | } | ANNUAL BENEFIT IN 1977 DOLLARS |
| BENEFIT OF SATELLITE-AIDED EMS TO TPS | = \$113 MILLION | | |

- THE FIGURE OF \$20,000 PER LIFE WAS USED SINCE IT IS NOT KNOWN HOW LONG A PATIENT LIVES AFTER BEING SAVED FROM A HEART ATTACK. FURTHERMORE, THE AGE STRUCTURE OF THE HATTIESBURG CARDIAC PATIENTS WAS NOT KNOWN. IF, FOR EXAMPLE, A MALE IN HIS MID-FIFTIES IS SAVED AND LIVES A FULL LIFE, THE VALUE COULD EASILY BE \$150,000 TO \$200,000 PER PATIENT.

2.1.3 REMOTE CARDIAC MONITORING

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RATIONALE FOR REMOTE CARDIAC MONITORING

Perhaps the two most important variables which determine the probability of surviving a heart attack are the quality of cardiac care and the timeliness of that care. In fact, while the survival rate nationwide for myocardial infarctions (MIs) is only 41 percent, fully 80 percent of those who receive intensive coronary care in a fully equipped coronary care unit (CCU) will survive.¹ A CCU is characterized by around-the-clock supervision of patients by trained cardiac care nurses, and cardiologists employing sophisticated equipment. The timeliness of this care is essential since 31 percent of all people suffering from MIs die within 24 hours.²

Upgrading both the quality and timeliness of cardiac care in rural areas is a difficult and costly proposition. First of all, trained cardiac care nurses and cardiologists are in short supply. Though ECON could not determine the number of cardiologists per 100,000 population, the number of specialists per above unit population is 30.3 in rural areas as opposed to 81.5 in metropolitan areas.³ A second problem affecting both the quality and timeliness of cardiac care in rural areas is that a CCU in each rural hospital would be economically infeasible. Even if there were a sufficient supply of trained medical personnel and capital, the lack of population density and, therefore, the small number of heart patients per hospital, would clearly make placement of a CCU in each hospital impractical. On the other hand, even if CCUs were placed according to some rule that reflected a desirable utilization rate as a function of population density, namely centralization of CCUs in regional hospitals, the travel time from remote locations to the central hospital would surely adversely affect the survival rate.

A possible solution to the three problems of (1) lack of medical personnel, (2) economic infeasibility of CCUs for each hospital and (3) timeliness of cardiac care, is the use of Remote Cardiac Monitoring (RCM) networks.

¹Cecil D. Burge, Some Potential Applications of a Public Service Satellite in Health Care Delivery, paper presented at Electro 77 Professional Program, New York City, April 19-21, 1977.

²Eve Weinblatt, Sam Shapiro et al., "Prognosis of Men after First Myocardial Infarction: Mortality and First Recurrence in Relation to Selected Parameters," American Journal of Public Health, 58, p. 1331, 1968.

³Office of Technology Assessment, U.S. Congress, The Feasibility and Value of Broadband Communications in Rural Areas. A Preliminary Evaluation, April 1976, p. II-3.

RATIONALE FOR REMOTE CARDIAC MONITORING

- THE NATIONAL HEART AND LUNG INSTITUTE ESTIMATES THAT OVER 600,000 PEOPLE SUFFER MYOCARDIAL INFARCTIONS (MI) ANNUALLY. THE NATIONAL MORTALITY RATE FOR MIs IS ROUGHLY 352,000 A YEAR.
- ROUGHLY 80 PERCENT OF THOSE VICTIMS WHO REACH A HOSPITAL AND RECEIVE INTENSIVE CORONARY CARE ARE SAVED. THE TIMELINESS OF THIS CARE IS ESSENTIAL SINCE THE MORTALITY RATE IS 31 PERCENT WITHIN 24 HOURS OF THE FIRST MI.
- IN RURAL AREAS, IT HAS BEEN ESTIMATED THAT 122,000 PEOPLE SUFFER FATAL MYOCARDIAL INFARCTIONS. UNFORTUNATELY, THERE IS AN ACUTE SHORTAGE OF CORONARY CARE NURSES, CARDIOLOGISTS AND FUNDS REQUIRED FOR CORONARY CARE UNITS (CCU).
- A SOLUTION TO SHORTAGE MAY BE THE USE OF REMOTE CARDIAC MONITORING (RCM) NETWORKS.

RATIONALE FOR SATELLITE-AIDED RCM

A remote Cardiac Monitoring (RCM) network allows transmission of a heart patient's vital signs from a smaller hospital (where fully equipped CCU is infeasible) to a centrally located major medical center. In this way patients and society benefit from centralization while at the same time care is provided locally so that travel time during the emergency is minimized. Each RCM bed in the smaller hospital can be equipped with a device that measures beats per minute (BPM) and another device that takes EKG measurements. This information is then sent via a conditioned data line to the central facility and monitored 24 hours a day by the medical personnel. Should trouble arise, each local hospital is equipped with a direct line for voice and alarms. Once the alarm is sounded, the physicians and nurses on duty may be instructed by the cardiologist at the central hospital on proper care, via the voice line.

Remote Cardiac Monitoring Networks are now operational in remote areas of Oklahoma, Illinois, Tennessee, and Mississippi. Though the use of these networks is clearly beneficial and cost effective, the introduction of new networks in other rural areas is held back due to poor reliability of rural telephone service and the high cost of conditioned phone lines in rural areas. As the following paragraphs will demonstrate, it is likely that an operational PSCS can be cost effective with conventional ground-based phone systems, given today's conditioned phone prices. Additionally, if a PSCS system can demonstrate higher reliability of telephone service than some current telephone systems, an operational PSCS will encourage installation of new RCM networks and will contribute to a reduction in the myocardial infarction mortality rates.

RATIONALE FOR SATELLITE-AIDED RCM

- CURRENTLY, AN RCM NETWORK ALLOWS TRANSMISSION OF A HEART PATIENT'S VITAL SIGNS FROM A SMALLER HOSPITAL TO THE CCU OF A MAJOR MEDICAL CENTER VIA EXISTING TELEPHONE LINES.
- FOR EACH RCM BED, A CONDITIONED DATA LINE AND A CONVENTIONAL LINE FOR VOICE AND ALARMS ARE REQUIRED. THESE LINES MUST BE BOTH RELIABLE AND HAVE A BACKUP CAPABILITY.
- PSCS IS A VIABLE SUBSTITUTE FOR THE CONVENTIONAL TELEPHONE NETWORK DUE TO:
 - + POOR RELIABILITY OF PHONE SERVICE IN SOME RURAL AREAS
 - + HIGH COST FOR CONDITIONED LINES.

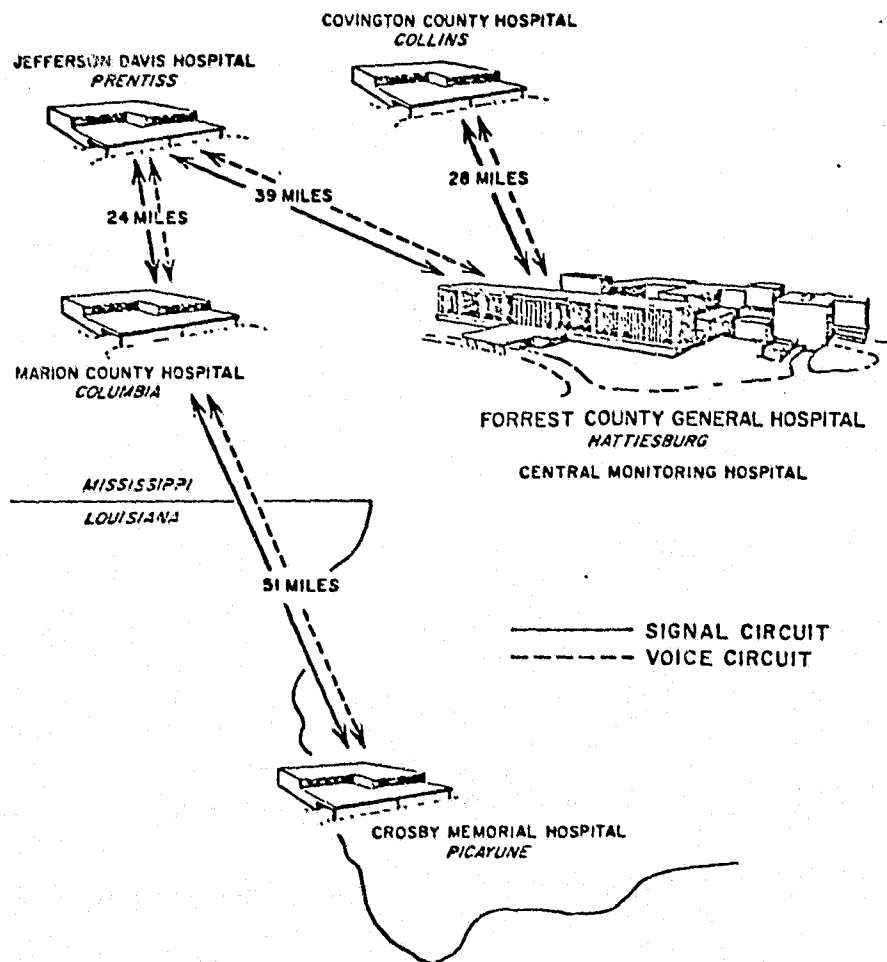
REMOTE CORONARY CARE PROGRAM FOR SOUTHEASTERN MISSISSIPPI

In order to evaluate the hypothesis that an operational PSCS could be a cost-effective substitute for a conventional phone system, ECON visited the RCM network located in southeastern Mississippi. The population served by the network numbers approximately 180,000, and covers seven counties. As can be seen on the map, the central hospital is located in Hattiesburg which lies in the center of the seven-county area. Each of the four remote hospitals employs two RCM beds, and is staffed 24 hours a day by at least one general practitioner and several nurses. The central hospital in Hattiesburg is the pride of the region, equipped with a very modern, fully staffed coronary unit. Trained nurses observe cathode ray tube terminals which display the heartbeats per minute of each patient on the network. If the BPM reading exceeds or is less than a predetermined interval, an alarm sounds and the EKG information is then automatically printed. The nurse alerts a cardiologist who picks up the direct line to the remote hospital to speak with the local nurse, who has already been alerted by the first alarm.

Though the present network includes only four hospitals, Dr. Brundage, co-director of the network, has stated that seven more remote hospitals plan to join in the near future. Two of these hospitals are more than 60 miles from Hattiesburg. To illustrate the need for reliability, Dr. Cecil Burge, chief engineer for the project, told of the hospital in Leeksville, Miss., which is served by a small independent telephone company. It appears that the company lacks a battery back-up capability, so that in the event of a power shortage all phone service in the area is lost. Though the hospital would be willing to join an RCM network, the reliability of its phone service is much too low.

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REMOTE CORONARY CARE PROGRAM FOR SOUTHEASTERN MISSISSIPPI



COST SAVINGS METHODOLOGY FOR MISSISSIPPI RCM NETWORKS

The cost savings methodology employed by ECON compared projected operating costs and amortized capital costs of the competing systems. The monthly service charge faced by the southeastern Mississippi RCM network is known for both the conditioned and voice lines. As is common practice, the South Central Bell Telephone Company includes a charge for apportioned amortized capital costs in its monthly charge. The network pays a fee which is not based on volume but is, rather, a fixed charge for 24-hour service on dedicated voice and conditioned lines. The charge works out to approximately \$11 per phone mile, per month. This standard unit of cost per phone mile will be used throughout the comparison.

On the other hand, it was necessary to forecast (based on several assumptions) the satellite ground station capital costs and the connectivity charge that would be faced by the network. It is believed that, even though the uncertainty behind the forecasts is high, a convincing case could be made for the cost-effectiveness of PSCS, even at unrealistically high projected satellite costs.

Once a break-even distance was computed, given the several assumptions, the next logical question was the magnitude of the savings that the Mississippi network could realize for hospitals lying outside the break-even radius. The social benefit of saving lives in those areas of southern Mississippi which would not join the network due to poor reliability was not computed. The assumptions and calculations are described in the following pages.

COST SAVINGS METHODOLOGY FOR MISSISSIPPI RCM NETWORKS

THREE IMPORTANT QUESTIONS:

- CAN A SATELLITE SYSTEM PROVIDE THE SAME OR EVEN BETTER SERVICE THAN THE EXISTING CONVENTIONAL PHONE LINE SYSTEM?
- IF SO, GIVEN ASSUMPTIONS ON SATELLITE CONNECTIVITY AND GROUND STATION COSTS, WHAT IS THE BREAK-EVEN DISTANCE IN MILES WHERE THE SATELLITE AND CONVENTIONAL SYSTEM COSTS ARE EQUIVALENT?
- ARE THERE ANY HOSPITALS IN THE SOUTHERN MISSISSIPPI RCM NETWORK WHICH LIE OUTSIDE THIS BREAK-EVEN REGION?

SOUTHEASTERN MISSISSIPPI COST SAVINGS BENEFITS

The methodology employed to compute the cost savings of a satellite-aided RCM network first compared the operating and capital costs of the alternative terrestrial versus satellite technologies. Attention centered on those operational and capital costs which were specific to the satellite system; for example, ground station and connectivity costs. Given the costs of the competing technologies, a "break-even distance" was computed parametrically as a function of differing assumptions on ground station, satellite and launch costs.

Due to uncertainties in forecasting the eventual satellite configuration, ground station and launch costs, it was difficult to estimate a single break-even distance for satellite versus a terrestrial RCM network. Therefore, several different combinations of ground station and connectivity costs were compared. Cost of a ground station capable of supporting two CCUs was varied from \$2000 to \$10,000, and amortized over 50 months, which is the industry standard. Based on a three-year payback, and assuming a 12-transponder configuration, the \$1.0M/transponder year corresponds to a \$36M launch and satellite cost. The \$1.25M/transponder year was based on a \$45M launch and satellite cost. It was assumed that each 35Mhz transponder could provide the equivalent of 600 phone lines. Each Coronary Care Unit uses 1.5 phone lines in southern Mississippi. Therefore, at \$1 M/transponder year the monthly connectivity charge for one CCU is \$208.33. At \$1.25 M/transponder year, the connectivity charge is \$260.42. Given this information, the break-even distance for an operational satellite RCM network was computed as follows:

$$\frac{\text{Ground Station Cost}}{50 \text{ months}} + (\text{Monthly Connectivity Cost}) \times 2 \\ = 2 \times (\$11/\text{mile}) \times \text{Distance}$$

By solving this equation for distance, the break-even point was derived. The break-even distance was computed assuming two CCUs per hospital, which is the case in the network in Mississippi. At this distance the satellite-aided RCM and terrestrial RCM have equal costs. The satellite is cost effective if the actual distance between hospitals is greater than the break-even distance.

The annual cost savings benefits can now be computed from:

$$\text{Benefits} = (\text{Actual Distance} - \text{Break-Even Distance}) \times 12 \text{ months} \\ \times \$11/\text{mile-month} \times 2 \text{ CCUs per hospital.}$$

The potential cost saving benefits were calculated for several possible break-even distances for the existing Mississippi RCM network. The "break-even distance" in any given situation is that distance where both technologies become competitive, not where one particular technology becomes economically feasible. As a result, break-even distance is a function of (1) satellite ground station costs, (2) satellite costs, including launch costs, (3) current cost per mile for conditioned phone lines, which is constant for this analysis, and (4) distance between any given rural hospital and the nearest hospital.

SOUTHEASTERN MISSISSIPPI COST SAVINGS BENEFITS

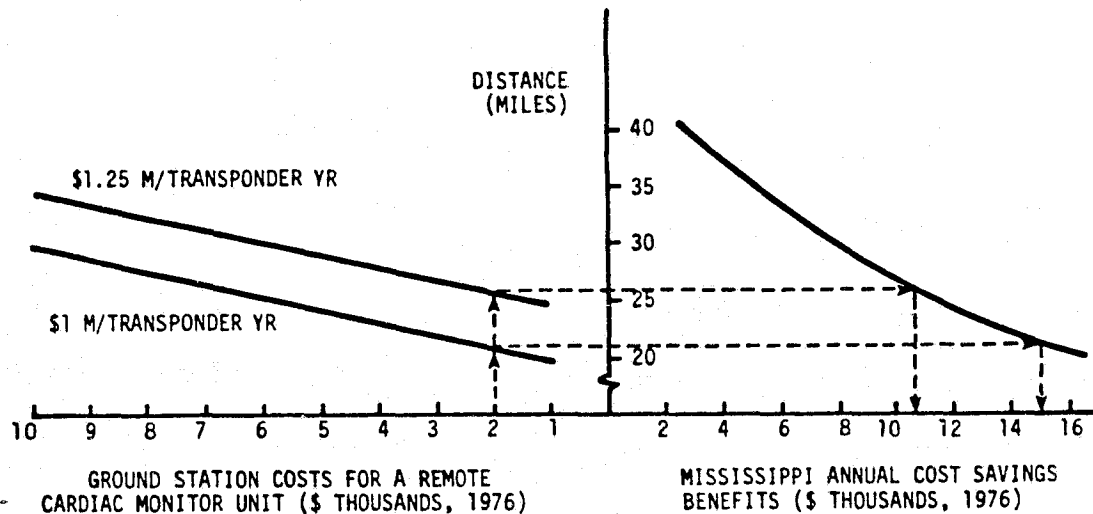
IF THE BREAK EVEN
DISTANCE IS:

THE ANNUAL COST SAVINGS
BENEFITS (1976\$)

| | |
|----------|--------|
| 40 MILES | 2,900 |
| 35 MILES | 5,280 |
| 30 MILES | 7,920 |
| 25 MILES | 11,350 |
| 20 MILES | 16,360 |

ASSUMPTIONS

- THE GROUND STATION COSTS WERE AMORTIZED OVER 50 MONTHS USING STRAIGHT LINE DEPRECIATION.
- EACH GROUND STATION AT A REMOTE HOSPITAL TRANSMITS AND RECEIVES OVER A 25 KHZ BANDWIDTH.



METHODOLOGY FOR GENERALIZATION OF MISSISSIPPI COST SAVINGS BENEFITS

Probably the most important factors affecting the accuracy of a nationwide generalization of the Mississippi results are population density, and location and quality of hospital care. In order to account for these influences, the American Hospital Association Index of Hospitals was used to locate each hospital in the thinly populated states. Having classified hospitals by their distance from the nearest hospital, the national benefits were computed again as a function of break-even distance. As the break-even distance decreases, based on satellite and ground station costs, the number of hospitals that may be included in the generalization increases. Distance between hospitals was computed by actually locating each hospital in a given thinly populated state on a scaled map. It was assumed that each hospital could support a coronary care unit and that the local telephone costs for conditioned voice lines would remain at \$11/phone mile.

METHODOLOGY FOR GENERALIZATION OF MISSISSIPPI COST SAVINGS BENEFITS

- THE CALCULATION OF COST SAVINGS BENEFITS FOR ALL RURAL AREAS IN THE UNITED STATES AS SCALED FROM THE MISSISSIPPI RESULTS DEPENDS ON:
 - + THE COST OF CONDITIONED PHONE SERVICE IN OTHER RURAL AREAS
 - + THE DISTANCES BETWEEN THE HOSPITALS INVOLVED.
- THE DISTANCE TO THE NEAREST HOSPITAL WAS COMPUTED FOR ALL HOSPITALS IN THE THINLY POPULATED STATES. HOSPITALS WERE INCLUDED IN THE GENERALIZATION IF THEY WERE FURTHER FROM THE NEAREST HOSPITAL THAN THE COMPUTED BREAK-EVEN DISTANCES.
- DIFFERENTIALS IN PHONE LINE COST AMONG THE RURAL STATES WERE NOT INCLUDED IN THE SCALING.

GENERALIZED COST SAVINGS BENEFITS FOR REMOTE CARDIAC MONITORING

Using the same methodology as was used for the Mississippi network, the cost savings benefits of satellite-aided RCM were computed for the thinly populated states. It was assumed that each hospital contained two CCUs.

$$\text{Cost Savings Benefits} = (\text{Actual Distance} - \text{Break-even Distance}) \\ \times \$11/\text{mile month} \times 12 \text{ months} \times 2 \text{ CCUs}$$

Taking the measured distance to the nearest hospital, the potential cost savings benefits were calculated for several break-even distances. As the break-even distance decreased the number of hospitals which could take advantage of satellite-aided RCM increased.

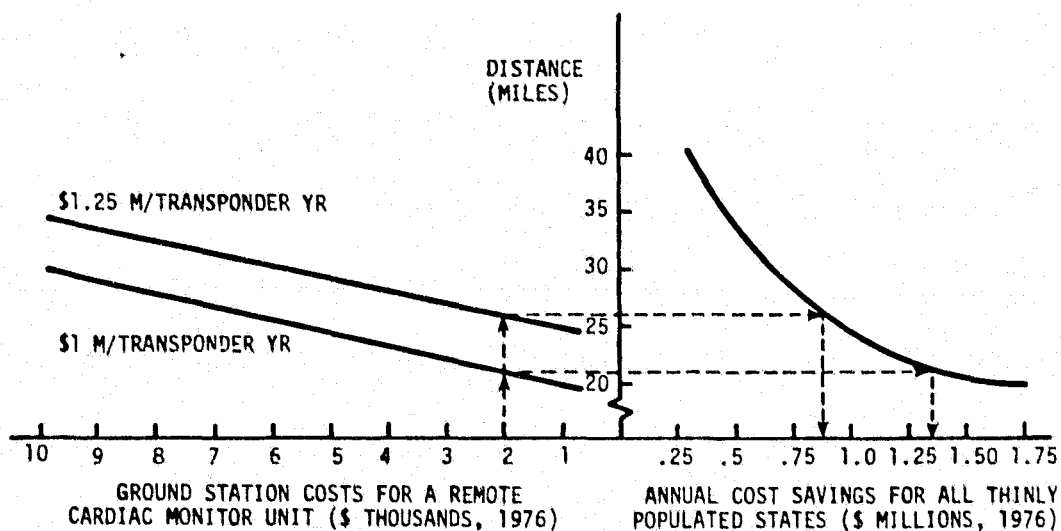
The cost saving benefits do not include the social benefits which could accrue for hospitals which do not currently have RCM because of the current high cost, or because of poor phone line reliability. If hospitals start RCM networks as a result of the satellite-improved communications service, then the benefits due to reduced myocardial infarction mortality could also be attributed to the PSCS system. This benefit area has not been addressed in this study.

GENERALIZED COST SAVINGS BENEFITS FOR REMOTE CARDIAC MONITORING

| <u>BREAK-EVEN DISTANCE (MILES)</u> | <u>NUMBER OF HOSPITALS</u> | <u>ANNUAL COST SAVINGS (\$ THOUSANDS, 1976)</u> |
|--|--------------------------------|---|
| 45 | 59 | 244 |
| 40 | 94 | 344 |
| 35 | 139 | 459 |
| 30 | 230 | 666 |
| 25 | 392 | 1,033 |
| 20 | 705 | 1,658 |

COMMENTS:

- IT IS ASSUMED THAT EACH HOSPITAL EMPLOYS ONE GROUND STATION AND TWO RCM BEDS.
- THE SOCIAL BENEFIT OF SAVING LIVES, ATTRIBUTABLE TO PSCS, IN A LIMITED NUMBER OF RURAL AREAS IS NOT INCLUDED.
- CONVENTIONAL PHONE LINE COST CONSTANT.



2.1.4 TELECONSULTATION

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RATIONALE FOR EXAMINING BENEFITS OF SATELLITE-AIDED TELECONSULTATION

Teleconsultation is a general term which denotes any remote communication between health professionals, including interpretation of medical data, whether they be nurses, paramedics, general practitioners or specialists. As such, each of the applications covered earlier are examples of teleconsultation. For example, remote cardiac monitoring represents a consultation between cardiologists, nurses and general practitioners. These applications were chosen since both the demand and technology could be defined based on existing operational systems.

The limited number of nurses, physicians and specialists in rural areas has caused a major imbalance in the morbidity and mortality statistics between rural and urban areas. Perhaps the quickest and most cost effective means to alleviate the problem is through teleconsultation, whereby nurses in the field, physicians at rural hospitals and even specialists in urban medical centers can communicate and disseminate knowledge and techniques. The proposed effect of such a system would be an increase in health professional productivity. The most cost-effective way to implement a consultation network may be by satellite, given the prohibitive costs of ground-based microwave relay towers. It should be understood that without specific definition of a PSCS operational system the cost-effectiveness of an operational PSCS system in comparison with ground technologies can only be approximated.

Unfortunately, a step-by-step approach to computing the benefits in the health area, though practical, seemed to run the risk of overestimation. In other words, it seemed desirable to see how the maximum possible benefit of the entire teleconsultation area compared with the benefits already computed for specific limited areas. If the benefit for a specific area was near the maximum possible for all teleconsultation, the results reported in the previous sections would seem suspect.

As a result, ECON computed the benefits of reducing the national mortality rate that would result from increases in the quantity of health professionals and medical capital. Since it is not known by how much a teleconsultation network would increase the productivity or effectiveness of existing health professionals, the numbers in this section are not to be interpreted as benefits of a PSCS teleconsultation network. The calculations here serve only to temper and assist in evaluating the benefit estimates of the specific medical applications described in Sections 2.1.1, 2.1.2 and 2.1.3 of this report.

RATIONALE FOR EXAMINING BENEFITS OF SATELLITE-AIDED TELECONSULTATION

- TELECONSULTATION DENOTES ANY REMOTE COMMUNICATION BETWEEN HEALTH PROFESSIONALS, INCLUDING INTERPRETATION OF MEDICAL DATA, WHETHER THEY BE NURSES, PARAMEDICS, GENERAL PRACTITIONERS OR SPECIALISTS.
- REMOTE CARDIAC MONITORING, EMERGENCY MEDICAL SERVICES, AND TELE-RADIOLOGY ARE EXAMPLES OF TELECONSULTATION. IN THOSE APPLICATIONS, IT WAS SHOWN HOW PSCS COULD IMPROVE THESE SERVICES.
- THERE ARE SEVERAL OTHER APPLICATIONS, INCLUDING DERMATOLOGY, OSTEOPATHY, AND TREATMENT OF TRAUMA EMERGENCIES, WHICH COULD ALSO BENEFIT FROM PSCS.
- THIS SECTION ATTEMPTS TO DETERMINE THE TOTAL DOLLAR BENEFITS DUE TO REDUCTIONS IN MORTALITY AS A RESULT OF A SATELLITE-AIDED TELECONSULTATION NETWORK.

OPERATION OF THE ALASKAN INDIAN HEALTH SERVICE TELECONSULTATION NETWORK

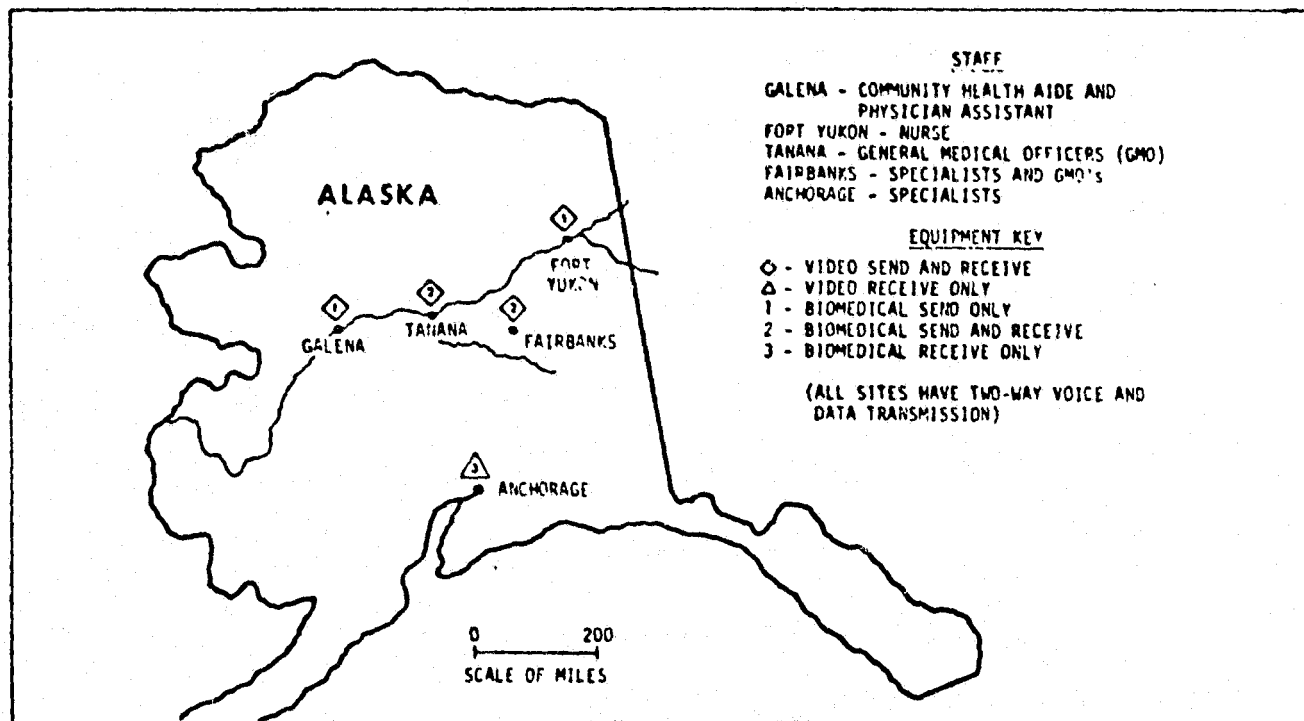
In order to define what is meant by an operational teleconsultation network, ECON analyzed one of the few experiments to date that comprehensively studied the many forms of telemedicine. The Alaska Area Native Health Service (AANHS) experiment¹ was run for approximately 9 months for some 350-odd patients, in late 1974 and early 1975. As can be seen on the facing page, the experiment originally was planned to provide expert consultation services from the major medical facilities in Anchorage and Fairbanks to physicians in Tanana and nurses in Galena and Fort Yukon. As it turned out, only Anchorage, Tanana, and Fort Yukon were involved in the experiment due to technical difficulties. The consultations were conducted by radio and television via ATS-6, for only three hours a week, though in emergencies a channel on ATS-6 could be made available. Typically, if a particular case required more expertise than the nurse in Fort Yukon could provide, the nurse would present the patient on the television screen to the specialists in Anchorage. At that time the determination was made on whether the patient should be transported to the major hospital in Anchorage. Those familiar with the project felt that this type of consultation could potentially decrease travel costs by eliminating unnecessary trips. Furthermore, it was felt that the interaction between the specialists and nurses in the Alaskan bush actually served to educate the nurses on the more complex diagnosis.

Unfortunately, since the Alaskan experiment was run for such a short time, there does not exist a suitable database on which to compute the travel cost savings or to measure any sort of productivity changes on the part of the health professionals involved.

¹ Martha Wilson and Charles Brady, "Health Care In Alaska Via Satellite," AIAA Conference on Communication Satellites for Health/Education Applications, Denver, Colorado, July 21-23, 1975.

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OPERATION OF THE ALASKAN INDIAN HEALTH SERVICE TELECONSULTATION NETWORK



METHODOLOGY FOR COMPUTING NATIONAL TELECONSULTATION BENEFITS

The ideal methodology for assessing national teleconsultation benefits would involve (1) determination of the relationship between teleconsultation and productivity improvements in health care delivery and (2) the relationship between improvements in health care and expected changes in mortality, morbidity, and cost-effectiveness. Of the two tasks the former is by far the most difficult since so little is known about the medical effectiveness of teleconsultation. In those applications where advanced technology was a direct substitute for a conventional medical technique (e.g., teleradiology or remote cardiac monitoring), the answer to the medical effectiveness issue was clear cut. As pointed out earlier, there has been only limited experience with a fully operational teleconsultation network, namely in Alaska and in Arizona.

As a result, the medical profession as a whole appears to be unwilling to judge the merits of teleconsultation. Though the physicians and nurses active in the IHS experiment in Alaska found ATS-6 valuable, it is not clear whether such a system would be cost effective or applicable for a significant number of patients in the continental United States. Therefore, lacking even a qualitative answer on the relationship between teleconsultation and quality changes in health care delivery, a quantitative assessment was impossible.

More is known on the relationship between improvements in health care and expected changes in mortality and morbidity. For example, a NBER report¹ studied the sensitivity of the national mortality rate to changes in medical services, as measured by number of health practitioners per capita. As can be seen on the facing page, medical services were subdivided into six distinct components including physicians per capita, and paramedics per capita. The report used a two-stage regression technique to estimate the "elasticity" of a given variable to the national mortality rate. The "elasticity" of an explanatory variable is simply its logarithmic derivative with respect to the dependent variable, in this case mortality.

Due to the specification of the model in the NBER report, the elasticities were the computed regression coefficients. Intuitively the elasticities can be interpreted as the percentage change in mortality given a one-percent change in the relevant explanatory variable, for example, paramedics per capita.

ECON used the NBER results to compute parametrically the number of lives that would be saved due to increases in medical services as a whole and then separately for increases in the number of paramedics per capita. The parametric approach was used since it is not known by how much an operational teleconsultation network would increase the number of effective medical professionals through the productivity change. The NBER results for the physicians-per-capita variable was statistically insignificant, and in fact, was positively related to mortality. A dollar benefit figure was then attached to the number of lives saved, using the "human capital" method.

It should be noted that a usual consumers' surplus approach to measuring the benefits of technological improvements in medicine would start with the demand for "good health." The reasoning asserts that consumers demand good health in order to realize higher future earnings since health maintenance allows one to work longer, and lose fewer working days to sickness. If consumers knew that a technological improvement in health care would improve physicians' productivity their demand curve for health would shift by an amount equivalent to the value of present discounted earnings that would be realized by the population once the morbidity and mortality rates decline. The demand for improved health care is a demand for a new good, but the demand is expressed as an income change. Unfortunately, it is very difficult to measure units of "good health." As a result, the time trend in mortality per unit population is often used as a proxy since the data is available, accurate and, importantly, is positively related to stock of "good health" of the population.

¹ Richard Auster, Irving Leveson, Deborah Sarachek, "The Production of Health an Exploratory Study" in Essays in the Economics of Health and Medical Care, Victor Fuchs, editor, (New York: National Bureau of Economic Research, 1972).

METHODOLOGY FOR COMPUTING NATIONAL TELECONSULTATION BENEFITS

- STATISTICAL RESEARCH HAS ESTIMATED THE DEGREE OF SENSITIVITY BETWEEN CHANGES IN THE FOLLOWING COMPONENTS OF MEDICAL SERVICES AND CHANGES IN OVERALL MORTALITY RATE:
 - PHYSICIANS PER CAPITA
 - PARAMEDICS PER CAPITAL
 - MEDICAL CAPITAL PER CAPITA
 - PRESCRIPTION EXPENDITURES PER CAPITA
 - PERCENT PHYSICIANS IN GROUP PRACTICE
 - PRESENCE OF A MEDICAL SCHOOL.
- FURTHERMORE, THIS RESEARCH HAS DERIVED THE SAME SENSITIVITY ESTIMATES FOR THE VARIOUS COMPONENTS OF "MEDICAL SERVICES" INCLUDING THE NUMBER OF PHYSICIANS, PARAMEDICS, AND QUANTITY OF MEDICAL CAPITAL.
- GIVEN THIS RELATIONSHIP, IT MIGHT SEEM POSSIBLE TO ESTIMATE BY HOW MUCH THE VARIOUS COMPONENTS OF MEDICAL SERVICES COULD BE INCREASED BY AN OPERATIONAL TELECONSULTATION NETWORK AND THUS THE POTENTIAL NUMBER OF LIVES SAVED.
- UNFORTUNATELY, ECON HAS FOUND THAT ESTIMATES OF THESE IMPROVEMENTS IN MEDICAL SERVICES WHICH WOULD BE ATTRIBUTABLE TO AN OPERATIONAL TELECONSULTATION NETWORK ARE NOT AVAILABLE FROM EXPERIMENTS PERFORMED TO DATE.
- AS A RESULT, ECON ESTIMATED PARAMETRICALLY THE BENEFITS OF AN OPERATIONAL PSCS SYSTEM, MEASURING THE VALUE OF EACH LIFE SAVED BY THE HUMAN CAPITAL APPROACH.

HUMAN CAPITAL APPROACH

Just as businessmen use Return on Investment to make decisions, social scientists use the Human Capital approach. The individual acts as an entrepreneur, making decisions regarding changes in his level of health, education, or training. He makes investment decisions concerning his stock of human capital, whereas in business the investment is in physical capital. Just as in business, the investment decision is based on the change in income associated with increased productivity due to the investment. In assessing the benefits of satellite-aided teleconsultation ECON only considered changes in income streams due to reductions in mortality. The benefits due to reduced sick time, reduced accident rates, or increased productivity due to raising the general level of health, were not included.

Human capital is measured by the present value of future earnings. The present value of earnings equals the discounted annual earnings times the probability of survival through that year. An operational satellite-aided teleconsultation system would change the probability distribution of survival. Since the potential change is unknown, several different possibilities were examined in estimating the benefits.

HUMAN CAPITAL APPROACH

HUMAN CAPITAL, OR LIVELIHOOD SAVING, IS THE MOST COMMONLY USED METHOD FOR ASSESSING THE VALUE OF REDUCING MORTALITY. HUMAN CAPITAL IS BASED ON THE PRESENT VALUE OF A PERSON'S EARNINGS STREAM. THAT IS:

$$\begin{array}{l} \text{POTENTIAL VALUE OF} \\ \text{HUMAN CAPITAL} \\ \text{(FOR A PERSON} \\ \text{n YEARS OF AGE)} \end{array} = \sum_{i=n}^{\infty} \frac{P(i) E(i)}{(1+R)^{i-n}}$$

WHERE E_i EQUALS THE EARNINGS IN YEAR i , AND P_i EQUALS THE PROBABILITY OF SURVIVING UNTIL YEAR i .

TO EVALUATE THE POTENTIAL TELECONSULTATION BENEFITS, THE DIFFERENCE BETWEEN TWO SUMS WAS COMPUTED. THE FIRST REPRESENTS THE VALUE OF HUMAN CAPITAL LOST DUE TO DEATH ACROSS 17 AGE GROUPS USING THE HISTORICAL MORTALITY RATE. THE SECOND REPRESENTS THE VALUE OF HUMAN CAPITAL LOST TO DEATH FOR THE SAME AGE GROUPS, EXCEPT THAT A LOWER MORTALITY RATE (REFLECTING THE USE OF TELECONSULTATION) WAS USED.

$$\begin{array}{l} \text{BENEFIT OF} \\ \text{TELECONSULTATION} \end{array} = \sum_{j=1}^{17} \sum_{i=n}^{\infty} \frac{P(i) E(i)}{(1+R)^{i-n}} - \sum_{j=1}^{17} \sum_{i=n}^{\infty} \frac{P^1(i) E(i)}{(1+R)^{i-n}}$$

ESTIMATE OF BENEFITS OF TELECONSULTATION FOR ALL THINLY POPULATED STATES

As pointed out previously, percentage increases in both medical services and paramedics per capita were used in a parametric analysis to estimate the number of lives saved, by age group, for the thinly populated states. Using standard human capital tables,¹ the present value of earnings was computed for each age group. In this way, the problems of overestimating the discounted earnings for an elderly person, or underestimating the earnings for a younger person, were avoided.² The difference in the sum of the discounted earnings by age group for those who would have survived with and without the availability of the teleconsultation services is then taken to be the benefit associated with providing the teleconsultation services.

It is interesting to note that the benefit estimate for the emergency medical service application corresponds to a 25-percent increase in the number of paramedics per capita. If there were 100-percent certainty with respect to the benefits estimated for the EMS application, the calculations here would imply that satellite-aided EMS would represent a 25-percent increase in paramedic productivity.

The results of the calculations for the entire medical services area indicates that a \$5 billion benefit might be an upper bound for the teleconsultation application, for this would represent a 100-percent increase in all medical services. Though only the benefits of saving lives are included here, it would seem that cost-savings benefits due to substitution of one technology for another are very small in comparison.

¹ Jan Paul Action, Measuring The Social Impact of Heart and Circulatory Disease Programs: Preliminary Framework and Estimates, (Santa Monica, California: Rand Corporation, April 1975), p. 101.

² The mortality data by age group is from: Vital Statistics of U.S.; 1973. Volume II - Mortality, U.S. Department of Health Education & Welfare, 1975. (HRA) 76-1102.

ESTIMATE OF BENEFITS OF TELECONSULTATION FOR ALL THINLY POPULATED STATES

| <u>% CHANGE IN MEDICAL SERVICES</u> | <u>BENEFITS (\$ MILLIONS, 1976)</u> |
|---|---|
| 1% | 38.6 |
| 5% | 193.2 |
| 10% | 386.4 |
| 25% | 1,343.9 |
| 100% | 5,375.6 |

| <u>% CHANGE IN PARAMEDICS PER CAPITA</u> | <u>BENEFITS (\$ MILLIONS, 1976)</u> |
|--|---|
| 1% | 7.3 |
| 5% | 36.7 |
| 10% | 73.4 |
| 25% | 183.4* |
| 100% | 734.4 |

* CORRESPONDS TO BENEFIT ESTIMATE FOR IMPROVED EMS IN TPS.

2.2 TELECONFERENCING

A SUBSTITUTE FOR BUSINESS TRAVEL
BY FEDERAL CIVILIAN AND MILITARY
RESEARCH & DEVELOPMENT AGENCIES

SUMMARY

Communications and transportation are means by which individuals can extend their environmental boundaries in order to interact with each other. Historically, the communications and transportation industries have had parallel growth patterns. The increases in travel have evidenced an increased necessity to communicate over large distances, thus leading to an increase in the number and complexity of communications facilities.

Business travel implies a face-to-face meeting of two or more individuals. The objectives of business travel could in many instances be accomplished by the utilization of telecommunications rather than by the physical displacement of people. A teleconference is defined as conducting that interaction between individuals via telecommunication links in lieu of a face-to-face exchange. The conventional telephone already substitutes for much travel. The addition of more advanced and interconnective telecommunications may enable far more productive and diversified modes of communications as substitutes for even more travel, thus leading to savings of travel costs and man-hours spent in travel.

This section outlines the estimation for the propensity to substitute teleconferencing for various types of business travel. Based upon the derived rates of substitutability for travel, potential cost-saving benefits have been calculated for travel and manpower expenditures. The data base utilized for this analysis was obtained largely from the NASA experience with audio teleconferencing.¹

It is the purpose of this study to estimate the cost saving benefits which might result from the use of teleconferencing in lieu of certain types of travel by civilian, military and defense-related federal agencies. To accomplish this, a benefit model is developed and used to extrapolate the savings as estimated from the NASA Audio Teleconferencing network experience. The utilization data used in this analysis has been limited to audio plus facsimile and has not considered the percentage increase of teleconferencing substitutability as a function of added video capabilities. The general data available for video teleconferencing systems is limited. The ERDA Visual Conferencing System utilization data has been considered in this study, however, the system has only been in operation for a short period and is used to substitute for a very specific business trip type.

As a result, all of the potential cost-savings developed here are based upon audio plus facsimile capabilities. These benefits are assumed to be conservative estimations at the lower end of a scale of potential savings for the most sophisticated teleconferencing capabilities currently available. Benefits have been well documented for audio systems; however, the available data for video teleconferencing substitutability is limited. The choices for future teleconferencing systems will require more extensive experimentation for the information basis to determine the level of services required for the future.

The generalization of benefits for civilian federal agencies is based upon the experience of NASA, predominantly a research and development organization. The benefits to ERDA are based upon the similarity in organization and missions of the two agencies. Other civilian agencies examined in this preliminary study (HEW, VA, GSA, DOT) differ from NASA and ERDA in composition, missions and mode of operation. Consequently, without further study the benefits estimated for these other agencies should be viewed with decreased confidence.

The estimated potential benefits for military and defense-related operations have been considered only for travel related to military research, development, testing and evaluation operations within the Department of Defense (DOD) and the three services (Army, Navy, and Air Force). Based upon the derived rates of substitutability for travel in the federal civilian research-oriented agencies of NASA and ERDA, the potential cost-savings were then calculated for the military RDT&E agencies.

Estimated cost savings to the six civilian federal agencies considered here range from \$50 to \$150 million annually. Similarly, military agencies engaged in RDT&E activities could save approximately \$44 million per year.

¹M. Connors, G. Lindsey, and R. Miller, "The NASA Teleconferencing System: An Evaluation," 1976.

SUMMARY

- TELECONFERENCING HAS BEEN DEMONSTRATED AS BEING SUBSTITUTABLE FOR VARIOUS TYPES OF BUSINESS TRAVEL.
- IT CAN BE ASSUMED THAT THE IMPLEMENTATION OF VIDEO TELECONFERENCING WILL GREATLY INCREASE THE SUBSTITUTABILITY OF TELECONFERENCING FOR TRAVEL.
- BENEFITS FROM TELECONFERENCING APPEAR TO BE \$50-\$150 MILLION ANNUALLY FOR THE SIX CIVILIAN GOVERNMENT AGENCIES. BENEFITS TO MILITARY AGENCIES ENGAGED IN RDT&E ARE APPROXIMATELY \$44 MILLION ANNUALLY.
- A NEED CURRENTLY EXISTS FOR DETAILED CASE STUDIES IN VIDEO TELECONFERENCING UTILIZATION.
- IN THE FUTURE, COMMUNICATIONS AND TRANSPORTATION WILL INCREASE.
- DURATION OF BUSINESS TRIPS IS DEPENDENT UPON NATURE OF MEETING RATHER THAN TIME-DISTANCE.
- AS COMPLEXITY OF INTERACTION INCREASES, THE NEED FOR FACE-TO-FACE INCREASES.
- ORGANIZATIONS MOST AFFECTED BY TELECONFERENCING WILL BE THOSE GEOGRAPHICALLY DISPERSED.

DEFINITION

Using the definition of a teleconference on the opposite page, it is believed that satellite communications can contribute to teleconferencing by reducing the cost of interconnectivity between participants, and by eventually providing the opportunity for two-way video communications at a price that is virtually independent of the physical distance between the conferees.

DEFINITION

TELECONFERENCE: A CONFERENCE IN WHICH THE PARTICIPANTS INTERACT VIA A TELECOMMUNICATIONS LINK IN LIEU OF A FACE-TO-FACE MEETING.

U.S. BUSINESS TRAVEL EXPENDITURES

According to the 1974 United States Travel Data Center's Yearly Travel Survey, more than 90 million business trips were taken in the United States during that year, of which over 30 percent utilized air transportation. Direct travel expenditures for business trips accounted for more than \$50 billion in 1974.

In order to evaluate annual business trip expenditures and potential savings to trip expenses through the implementation of teleconferencing, the component costs of business trips were analyzed. The cost of a business trip was divided into "out-of-pocket" costs (i.e., the direct travel expenditures) and working time costs.

"Out-of-pocket" costs consist of long-haul transportation expenses, per diem subsistence costs for food, lodging, miscellaneous, and ground transportation. Trip costs were calculated for the average trip distance in miles in six trip-distance categories ranging from 200 miles to over 2000 miles round trip. (See Trip Distance and Meeting Categories, page 95.) Business trips less than 200 miles (round trip) were not included as a category since statistics are not generally available for these shorter trips. Short trips generally occur during a single day, incur only ground transportation, food, and man-hour expenses. Though these trips may be more numerous compared to the longer, more costly business trips, it is difficult to find accurate short-trip data in order to develop a trip profile for expenditures and trip frequency.

The benefits of teleconferencing are considered to be cost-savings benefits which are the direct result of substituting teleconferencing for business travel. The cost-savings benefits are therefore the direct travel and man-hour costs which could be foregone, less the cost associated with the teleconferencing which is substituted for travel.

U.S. BUSINESS TRAVEL EXPENDITURES

GENERAL PRINCIPLES

- MORE THAN 90 MILLION BUSINESS TRIPS ARE TAKEN EACH YEAR IN THE UNITED STATES
- 19% OF INTERSTATE BUSINESS TRIPS REPRESENT LOST WORKING TIME
- 40% OF ALL BUSINESS TRIP TIME REPRESENTS LOST PERSONAL TIME
- TELECONFERENCING CAPABILITIES IMPLY AUGMENTING BUSINESS COMMUNICATIONS AND SUBSTITUTION OF VARIOUS TYPES OF BUSINESS TRAVEL RESULTING WITH HIGHER BUSINESS EFFICIENCY AND PRODUCTIVITY

PARADIGM FOR TELECONFERENCING TARGET MEETINGS

The substitutability of teleconferencing has been found to be a function of a number of variables.¹ It is anticipated that teleconferencing will not substitute for travel by sales people, clerical staff or skilled craftspeople. It is believed that recurring, routinized business interactions, generally involving professional, executive and management personnel, which occur at geographically dispersed locations, accounts for the greatest number of business trips for which teleconferencing could be substituted.²

Business travel which involves personal transportation of information, rather than material or inspection interactions, has a great propensity to substitution by teleconferencing.¹ It is believed that intra-firm business travel and communications between geographically dispersed facilities could be greatly affected by the potential of teleconferencing services.

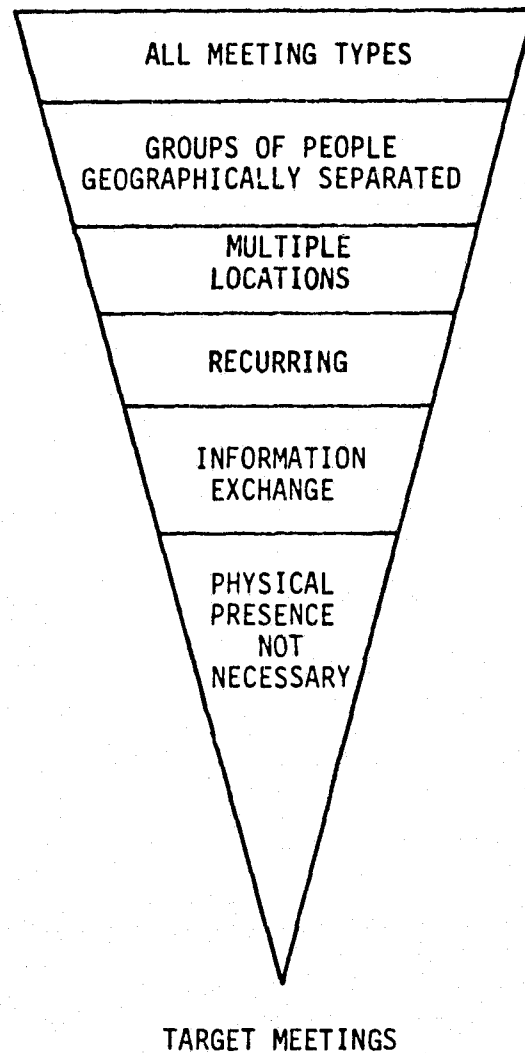
Generally, as the complexity of the communication task increases, the greater the perceived need for face-to-face contact and the requirement for more sophisticated teleconferencing facilities which would substitute for travel (i.e., video).³ Average telephone communication between two parties may be considered as a most simplistic teleconference. The basic available audio service between two parties may then be extended to multiple nodes; graphics and hard copy availability may then augment the service; computer-to-computer interconnections may then be provided on an interactive basis; video transmission may then augment the audio service to two or multiple nodes. The potential designs for operational teleconferencing networks range from the two-node land line telephone network, to the most complex video satellite transmission system, each fulfilling specific communications needs of the interactions.

¹Lawrence Day, "Factors Affecting Future Substitution of Communications for Travel," (Bell Canada, October 1974).

²Peter McManamon, "Technical Implications of Teleconference Service," IEEE Transactions in Communications, Vol. Com-23, No. 1, January 1975.

³Dr. Arthus Kahn and Herb Nunnally, "Conducting Teleconferencing Experiment Oriented to Private Industry Applications Via the Communications Technology Satellite," Westinghouse Electric Corp., Maryland, February 1977.

PARADIGM FOR TELECONFERENCING TARGET MEETINGS



CONTEMPORARY TELECONFERENCING SYSTEMS

The NASA Audio Teleconferencing Service and the ERDA Video Conferencing Service (EVCS) were selected from the various operational teleconferencing systems as the basis for ECON's benefit model for generalizing teleconferencing cost-benefits for travel substitution to other civilian federal agencies.

The NASA teleconferencing experience was well documented in 1976 after a full year of service operation. The ERDA Video Conferencing Service has been only preliminarily evaluated for manpower savings after 15 months of service; however, future experience with the EVCS could provide a basis for a generalization of potential savings due to a video teleconferencing service for civilian government applications.¹

¹Private communications with Charles Brasheares, Assistant Director for Telecommunications, ERDA, June 29, 1977.

CONTEMPORARY TELECONFERENCING SYSTEMS

Audio Systems

Remote Meeting Table (U.K.)

* NASA

Univ. of Quebec (Canada)

Department of
Communications (Canada)

Department of Indian
& Northern Affairs
(Canada)

* General Services Administration

New Rural Society
Project (Union Trust
Company)

* General Electric

Bank of America

Video Systems

Bell Canada

* Bell Laboratories

Confravision (U.K.)

Confravision (Europe)

* AT&T Picturephone
Meeting Service

First National City
Bank

Bankers Trust Company

* General Electric

Australian Post Office

Dow Chemical

New York Telephone

Nippon T&T (Japan)

* Metropolitan Regional
Council

* ERDA

* Westinghouse

* Organizations contacted during this study.

AUDIO USAGE CHARACTERISTICS

The NASA and other teleconferencing experiences with audio plus facsimile indicate that teleconferencing is appropriate under some conditions, face-to-face meetings under others.¹ The nature of the meeting is the prime determinant of the applicability and substitutability of a teleconference in lieu of travel. It was found that for meetings of routine matters of information exchange, teleconferencing is the preferred mode. If the meeting is important and complex (especially involving negotiations), a face-to-face meeting is preferred. Teleconference participants placed high value on their time and competing commitments and on saving the costs of travel (this seems to be particularly true when tight constraints are placed upon travel budgets). It was found that those who made the most use of teleconferencing tended to shift travel allocations away from project endeavors and towards conference-related travel, a finding supportive of a partial substitution hypothesis.²

Teleconference participants are generally mid- to senior-level administrators and executives. Teleconferences are usually from one to two hours in duration.

Teleconference nodes which have been investigated during this study cover a wide range of individual terminals (for example, Bell's 50-A) to large, specially designed conference centers. Many of the audio networks listed here include facsimile transmission.³

¹Lawrence Day, "Factors Affecting Future Substitution of Communications for Travel," (Bell Canada, October 1974).

²R. W. Hough, "Teleconferencing Systems. A State-of-the-Art and Preliminary Analysis," prepared for National Science Foundation, Division of Advanced Technology, Research and Technology, Washington, D.C., (Stadford Research Institute, April 1977).

³Ibid.

Audio Usage Characteristics*

| Audio Systems | Organizational Level | Organizational Function | Meeting Frequency | Meeting Duration (hrs) | No. of Participants | Meeting Type ** | Status |
|--|--------------------------|------------------------------|-------------------|------------------------|---------------------|-----------------|-------------|
| Remote Meeting Table (U.K.) | mid to senior level mgt. | civil servants | 1-3/week | 2 | 3-6 | 1-4 | operational |
| NASA | mid to senior level mgt. | admin., proj. mgt., research | 20-30/week | 2-3 | 32 (ave.) | 1-3,7 | operational |
| Univ. of Quebec (Canada) | various | admin., teaching | 3-4/week | 1-2 | 6-10 | 1-4 | operational |
| Department of Communications (Canada) | mid-senior level | mgt., staff | 1-2/week | 1-2 | 6-10 | 1,2 | operational |
| Department of Indian & Northern Affairs (Canada) | mid-senior level | mgt., staff | 1-2/week | 1-2 | 6 | 1,2 | operational |
| General Services Admin. | various | n.a. | n.a. | 1 | 10-20 | + | operational |
| New Rural Society Project (Union Trust Company) | senior level mgt. | mgt. committee | 3-5/week | 2-3 | 8-12 | 1,2 | operational |
| General Electric | staff and mgt. | proj. staff mostly | 8/week | 1-2 | 4-8 | 1-3,7 | operational |
| Bank of America | senior level mgt. | high level committee | 10-15/week | 2-4 | 8-16 | 1,2 | operational |

*Extracted from Hough, R.W., Teleconferencing Systems: A State of the Art Survey and Preliminary Analysis, Stanford Research Institute, May 1976.

** (1) routine business meetings, (2) informal information exchange, (3) urgent meetings, (4) meetings prior to face-to-face meetings, (5) teaching, training or instruction, (6) sale presentations, (7) research.

+Most meetings to date have been for demonstration and to "show-off the System".

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VIDEO TELECONFERENCING SYSTEMS--USAGE CHARACTERISTICS

The specific teleconference terminal design, the mode of available communication service (i.e., audio, facsimile, video and their combinations), the form of available service (i.e., in-house or public), the specific teleconference applications considered, and the current cost of communications services have had a major effect upon the current and near-term role of teleconferencing. Current video teleconferencing usage is summarized in the accompanying table. The variability of results is apparently the result of the particular application for which teleconferencing has been employed, the particular hardware configuration (for example, it has been demonstrated that stereo systems are much preferred to monaural systems for group audio teleconferences), the previous experience of the audience with teleconferencing, the communications service cost, the public or private (in-house or for public use) nature of the system, etc.

The Bell Labs experience with video teleconferencing indicates that about 50 percent of the users would prefer to use teleconferencing rather than travel 15 miles, or drive a half hour for a face-to-face conference. Ninety-one percent would use it rather than travel 50 miles, or an hour and a half.¹

The General Electric Sampledot system has a half-duplex video capacity and full-duplex audio capacity between GE facilities at Valley Forge, Pennsylvania and Daytona Beach, Florida. Each teleconference between these two nodes replaces a six-hour trip which averages \$358 per trip.² This accounts basically for a \$176 plane fare, plus ground expenses, subsistence and man-hours for travel time.

The ERDA Video Conferencing System is the first video teleconferencing network for a federal agency. This network connects the Germantown, Maryland facilities with the 20 Massachusetts Avenue, Washington, D.C. offices and replaces a three-hour commute on the ERDA shuttle bus service. The actual increase of the rate for substitutability of teleconferencing for travel has not been calculated for the EVCS because of the very limited nature of the system and the paucity of utilization data.³

¹Private communication with Michael Neil and Helen Knoll at AT&T office, Basking Ridge, New Jersey, May 1977.

²R. F. Stone, GE intra-company proprietary memo re: Sampledot, May 1977.

³Private communication with Charles Brasheares, Assistant Director of Telecommunications, ERDA, June 29, 1977.

Video Teleconferencing Systems - Usage characteristics*

| Video Systems | Organizational Level | Organizational Function | Meeting Frequency | Meeting Duration (hrs) | No. of Participants | Meeting Type ** | Status |
|-----------------------------------|---------------------------|-----------------------------|---------------------------------------|------------------------|---------------------|-----------------|----------------------|
| Bell Canada | mid-upper management | managerial, staff | in-house, about 1/day | 2.3 (ave.) | 3-6 | 1-3 | operational in house |
| Bell Laboratories | tech. staff to tech. dir. | management, research | about 2-4/week | 2.1 (ave.) | 3-6 | 1-3, 7 | operational |
| Confravision (U.K.) | senior mgt. | managerial, staff | modest usage | 1-2 | 6-8 | 1-3 | operational |
| Confravision (Europe) | senior mgt. | managerial, staff | very little so far | n.a. | n.a. | 1-3 | operational |
| AT&T Picturephone Meeting Service | various | various | in-house, modest; public, very modest | 1-2 | 4-6 | 1-3 | operational |
| First National City Bank | senior mgt. | money market management | out of service ⁺ | 1-3 | 3-6 | 1 mostly | out of service |
| Bankers Trust Company | senior mgt. | money market management | out of service ⁺⁺ | 1-3 | 3-6 | 1 mostly | out of service |
| Australian Post Office | various | managerial, staff, research | modest usage | 1-2 | 6 | 1-7 | operational |
| Dow Chemical | tech. staff, senior mgt. | research administration | 1-3/week | 1 | 3-6 | 1,2,7 | operational |
| New York Telephone | managerial staff | managerial, staff | very modest usage | 1-2 | n.a. | 1-3 | operational |
| Nippon T&T (Japan) | senior mgt. | research, administration | n.a. | 2 | 4-6 | n.a. | operational |
| Metropolitan Regional Council | clerks to executives | training, inter-govt. comm. | 30 hours/week | 1 | 10-100 | 5 mostly | operational |
| General Electric | mid-senior management | managerial | every day | 1-3 | 3-6 | 1-7 | operational |
| Westinghouse | management | managerial training | very little | — | 3-6 | 2,5 | operational |
| ERDA | management | managerial | 3-4/week | 1 hour | 5-6 | 1-5,7 | operational |

* Extracted from Hough, R.W., Teleconferencing Systems: A State of the Art Survey and Preliminary Analysis, Stanford Research Institute, May 1976.

** (1) Routine business meetings, (2) informal information exchange, (3) urgent meetings, (4) meetings prior to face-to-face meetings, (5) teaching, training or instruction, (6) sale presentations, (7) research.

⁺Very heavy, at an average of 50 meetings per week, when operational

⁺⁺Reasonably constant at about 3-5 meetings per week when operational.

TELECONFERENCING BENEFIT ESTIMATION

Based upon the NASA audio teleconferencing experience, a model was developed to estimate the potential benefits which might result from the substitution of teleconferences for certain types of business trips.

The benefits of teleconferencing are established as cost-saving benefits. The cost-savings benefits are obtained by establishing the true travel cost of all business travel from which is subtracted the cost of trips which cannot be foregone by teleconferencing and the cost of telecommunications for those trips for which teleconferencing is substituted for travel.

The cost of business trips is a function of the total number of trips, average cost of transportation per mile, ground and subsistence expenses. In addition to these out-of-pocket costs, manhours and overhead charges are also applied to the cost of a trip to generate the true travel costs.

The facing page presents the set of equations which are used to estimate teleconferencing cost-savings benefits. The variables used in these equations are defined as follows:

- N = Total Number of Trips
- i = Trip Type Category
- j = Trip Distance Category
- P_j = % of Trips in Distance Category j
- TC_j = Average Transportation Cost
- SC_j = Average Subsistence Cost Per Day (\$/Day)
- TD_j = Average Trip Duration (Person-Nights)
- TD'_j = Average Trip Duration (Work Hours)
- GT_j = Average Ground Transportation Per Day (\$/Day)
- WR = Hourly Wage Rate
- OH = Overhead Rate (%)
- NR_j = Average Number Teleconferences Required to Replace Trip
- K_i = % of Trips in Type i ($\sum_i K_i = 100\%$)
- F_i = % of Trips in Type i Which may be Foregone Through the Use of Teleconferencing
- TCD_i = Average Teleconferencing Duration (Hours)
- TEC_i = Teleconference Cost (\$/Hour)

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TELECONFERENCING BENEFIT ESTIMATION

$$\text{TOTAL TRAVEL BUDGET} = \frac{N}{100} * \sum_j P_j * C_j \quad \left\{ \begin{array}{l} \text{The set of } P_j \text{ is estimated such} \\ \text{that this relationship is true.} \end{array} \right\}$$

AVERAGE TRIP COST BASED UPON ROUND TRIP DISTANCE

$$C_j = TC_j + TD_j * (SC_j + GT_j)$$

TOTAL TRAVEL COST INCLUDING MANPOWER COST AND OVERHEAD

$$TTC_j = \frac{N}{100} * P_j * \left\{ C_j + TD_j * WR * \left(1 + \frac{OH}{100} \right) \right\}$$

COST OF TRIPS WHICH COULD NOT BE REASONABLY FOREGONE BY TELECOMMUNICATIONS

$$TCC_j = \frac{N}{100} * P_j * NR_j * \sum_i \left\{ \frac{K_i}{100} * \frac{F_i}{100} * TCD_i * \left[TEC_i + WR * \left(1 + \frac{OH}{100} \right) \right] \right\}$$

COST OF TELECOMMUNICATIONS FOR THOSE TRIPS WHICH COULD BE FOREGONE

$$TCC'_j = \frac{N}{100} * P_j * \left\{ C_j + TD_j * WR * \left(1 + \frac{OH}{100} \right) \right\} * \left\{ 1 - \sum_i \frac{K_i}{100} * \frac{F_i}{100} \right\}$$

TOTAL COST-SAVINGS BENEFITS OF TELECONFERENCE SERVICE

$$BEN_j = TTC_j - \left\{ TCC_j + TCC'_j \right\}$$

TRIP DISTANCE AND TYPE CATEGORIES

In order to evaluate the costs of business trips based upon the NASA experience, a disaggregation of total trips into six trip-distance categories was developed. The percentage of the total trips which fall in each distance category was then estimated and used to derive the average costs of those trips for each category.

The types of business trips generally taken have also been categorized. Business trip type has been related to the type of business to be conducted, namely the type of meeting to be attended. NASA found that approximately 75 percent of all meetings dealt with interactions concerning such things as project evaluation and planning, while only 11 percent were for administrative inter-actions. The propensity for substitution by teleconferences was assumed to be different for different types of meetings. The data concerning utilization of teleconferencing facilities by NASA personnel has substantiated this assumption. NASA experience indicates that for nearly 45 percent of the project-type meetings, teleconferences could be substituted for travel; whereas only 20 percent of administrative and 8 percent of scientific/technical associated travel could be replaced by teleconferencing.¹

Total trip cost can be calculated as follows:

$$\begin{aligned} \text{Total Trip Cost} = & \{(2 \times \text{One-way Trip Distance} \times \text{Cost Per Mile}) \\ & + (\text{Trip Duration} \times \text{Daily Subsistence Rate}) \\ & + (\text{Trip Duration} \times \text{Daily Ground Transportation Rate})\} \\ & + \{(\text{Working Hours} \times \text{Wage Rate}) \times (1 + \text{Overhead Rate})\} \end{aligned}$$

Total trip cost, as well as its two component parts, are illustrated on the facing page as a function of one-way trip distance. It should be noted that the cost per mile, trip duration, and working hours are functions of the one-way trip distance. Travel (both long-haul and ground) costs were derived from the Official Airline Guide, Volumes 1 and 2, November 1, 1976. The long-haul cost ranges from approximately 8¢/mile for 2000-mile to 20¢/mile for 150-mile trips. An average ground transportation rate of \$26/day was estimated.¹ This was based upon the assumption that for each trip a mid-size class car was rented and driven an average of 50 miles per day. Taxi service generally is more expensive than car rentals, so the assumption of \$26/day includes car or taxi utilization, as the costs would be expected to be about the same.

Trip duration, according to the U.S. Travel Data Center's Yearly Travel Survey for 1974, is related to trip distance, ranging from approximately 1.2 nights for a 100-mile (one-way) trip to 6.8 nights for a 2000-mile (one-way) trip.² The facing page illustrates the general business trip expense as a function of distance. Trip duration has been based on the U.S. Travel Data Center's Survey, estimated as corresponding to trip durations of 1.75 and 7 days, respectively, and 14 and 56 working hours, respectively.³

¹Mary Connors, G. Lindsey and R. Miller, "The NASA Teleconferencing System: An Evaluation," May 1976.

²This assumes an eight-hour working day times the average trip duration associated with the one-way trip distances ($1.75 \times 8 = 14$ and 14 working hours corresponding to 1.2 trip nights).

³U.S. Travel Yearly Survey 1974, U.S. Travel Data Center.

TRIP DISTANCE AND TYPE CATEGORIES

| | <u>ROUND TRIP MILES</u> | <u>AVERAGE ONE-WAY DISTANCE</u> | <u>AVERAGE NIGHTS PER TRIP</u> |
|-------|-----------------------------|-------------------------------------|------------------------------------|
| j = 1 | 200 - 299 | 125.9 | 1.22 |
| 2 | 300 - 399 | 173.4 | 1.42 |
| 3 | 400 - 599 | 249.2 | 2.73 |
| 4 | 600 - 999 | 393.3 | 3.28 |
| 5 | 1000 - 1999 | 694.1 | 4.08 |
| 6 | 2000 + | 1679.1 | 6.82 |

TRIP (MEETING) TYPE CATEGORIES

- | | |
|-------|---|
| i = 1 | PROJECT--RTOPI REVIEWS, DESIGN AND INSPECTION, PLANNING, ENGINEERING |
| 2 | ADMINISTRATIVE--MANAGEMENT TRAINING, BUDGET, PLANNING |
| 3 | MEETINGS--SCIENTIFIC AND TECHNICAL MEETINGS AND CONFERENCES |

NASA AUDIO TELECONFERENCING EXPERIENCE

The NASA Audio Teleconferencing Pilot Program began in 1975 as a result of a successful 1969 Apollo Program teleconferencing network.¹ The initial evaluation of the Apollo Program network indicated that program travel expenses had been decreased by 20 percent as a result of substituting teleconferences for program travel. NASA believed that expanding this teleconferencing network to all of its major installations would potentially save overall agency costs of energy, transportation and man-hours.

Currently, 34 rooms are equipped with 4-wire, switch use, voice-activated microphones and Bell 50-A portable conference telephones and facsimile to augment the audio network.

After one year of operation (1975), an evaluation of the project was conducted. It was found that of the reported teleconferences,² the average attendance was 27-28 people and involved 3.4 terminals with a meeting duration of approximately 2.9 hours. It was estimated that approximately 4,663 business trips were foregone by teleconferencing for an out-of-pocket travel expenditures savings (no manpower costs or overhead included) of \$1.4 million.

¹Mary Connors, G. Lindsey and R. Miller, "The NASA Teleconferencing System: An Evaluation," May 1976.

²A later evaluation of the 1975 survey data indicates that only about one-third of the total teleconferences were actually reported.

NASA AUDIO TELECONFERENCING EXPERIENCE

- TELECONFERENCING PROGRAM BEGAN IN JANUARY 1975 AS A RESULT OF 1969 APOLLO PROGRAM
- CURRENTLY 34 TELECONFERENCING ROOMS ARE INTERCONNECTED VIA MSFC SWITCHBOARD AT HUNTSVILLE, ALABAMA
- TELECONFERENCING ROOMS ARE EQUIPPED WITH 4-WIRE SWITCH USE VOICE-ACTIVATED MICROPHONES AND BELL 50-A PORTABLE CONFERENCE TELEPHONES ON 2-WIRE DEDICATED CIRCUITS
- ALL ROOMS CAN USE PROJECTORS, VISUAL AIDS, GRAPHICS AND CAN TRANSMIT FACSIMILE TO 47 TERMINALS
- THE COST OF PROVIDING SERVICE WAS APPROXIMATELY \$157,344 FOR 1975 OR \approx \$13,000/MTH.
- ESTIMATED THAT IN 1975 4,663 TRIPS WERE FOREGONE RESULTING IN TRAVEL SAVINGS OF \$1.4 MILLION.

NASA TELECONFERENCING COSTS AND SAVINGS¹

It was conservatively estimated that 4,663 business trips were foregone by NASA personnel during CY 1975. A spot check of 1974 travel expenses shows that the "average" NASA business trip cost approximately \$309. This should be considered a low average cost since this is an average of all trip types, including local day trips which involve minimal transportation expenses. Based upon NASA's 1978 in-house travel appropriations of \$18 million, approximately 58,000 business trips would be taken by NASA personnel with an average cost of \$309 per trip. Calculating the costs of the trips which were foregone as a result of teleconference substitution, the travel costs saved by teleconferencing were \$1,440,867.

The savings associated with the cost of manpower and overhead are in addition to out-of-pocket savings. Approximately 12,600 man-hours were saved during that first year of an operational system. Using an hourly wage of approximately \$13/hour and an average overhead charge of 132 percent,² an additional \$382,157 was saved in manpower expenses.³

Conservatively, NASA was able to save more than 10.5 times the cost of the teleconferencing service, for a 1975 total trip, man-hour and overhead savings of \$1,666,000 (after subtracting the cost of teleconferencing).

¹Mary Connors, G. Lindsey and R. Miller, "The NASA Teleconferencing System: An Evaluation," May 1976.

²Information obtained from NASA indicates that the overhead rate, including the 10 percent Headquarter overhead burden, varies from a low of 79 percent to a high of 202 percent for nine major NASA installations.

³Private communication with Mark Gielecki, NASA, Goddard Space Flight Center, July 25, 1977.

NASA TELECONFERENCING COSTS AND SAVINGS

ESTIMATED FOR CY 1975:

| | |
|-------------------|---|
| 4,663 | TRIPS REPORTED SAVED |
| \$1,440,867 | TRAVEL COSTS REPORTED SAVED |
| \$ 157,344 | TELECONFERENCING COSTS |
| \$1,283,523 | SAVINGS TO NASA* |
| <u>\$ 382,157</u> | MANPOWER SAVINGS (INCLUDING OVERHEAD 132%) |
| \$1,665,680 | TOTAL SAVINGS |

_____* Manpower costs not included.

POTENTIAL COST SAVING BENEFITS TO NASA

Based upon the NASA 1976 Teleconferencing Evaluation, the ECON benefit model was utilized to generate the potential cost-savings benefits to NASA as a result of trip expenses and man-hours foregone due to teleconferencing's substitutability for types of business trips.

The "out-of-pocket" expenditures for an average round-trip business meeting ranged from \$131 to \$1,743 dollars, depending on trip-distance category. This was based upon a \$35 subsistence per diem plus an average of \$26 dollars per day ground transportation, which were added to the average long-haul costs per trip mile. Trip duration was a function of trip distance.

Total trip costs were then calculated including "out-of-pocket" trip costs plus man-hour and overhead charges as a function of each trip-distance category. The average wage rate used was \$13 dollars per hour with a 132 percent overhead charge.¹ Based on this, total trip costs for all NASA business travel (included in the six distance categories), was estimated at about \$85 million annually.

Based upon the NASA evaluation, a conservative 37 percent was used as the total percentage of all trip types in all distance categories which could reasonably be foregone by using teleconferencing. Assuming a transmission cost of \$13.75 per hour,² it was estimated that NASA would be able to achieve annual cost-savings benefits of about \$11.9 million. These cost-savings benefits included the travel costs foregone as well as reduced travel time costs (including overhead).

¹Based upon an analysis of overhead rates of nine NASA facilities plus 10 percent agency overhead rate.

²Based upon current two-way 5KHz audio available 7 days per week, 24 hours per day.

POTENTIAL COST SAVING BENEFITS TO NASA

- THE AVERAGE OUT-OF-POCKET EXPENDITURES FOR TRAVEL RANGE FROM \$131 TO \$1,743 DEPENDING ON TRIP-DISTANCE CATEGORY
- APPROXIMATELY 37 PERCENT OF ALL TRIPS COULD BE FOREGONE BY TELECONFERENCING
- TRUE TRAVEL COSTS FOR TRIPS WHICH COULD NOT BE FOREGONE (63 PERCENT OF THE TOTAL BUSINESS TRIPS) ARE APPROXIMATELY \$66.5 MILLION ANNUALLY
- ASSUMING A CURRENT COST OF \$13.75 PER HOUR FOR AUDIO TELECONFERENCING SERVICE, ANNUAL COST-SAVING BENEFITS IN THE AMOUNT OF \$11.9 MILLION MAY BE ACHIEVED BY NASA.

PRELIMINARY NASA BENEFITS BY TRIP DISTANCE CATEGORIES

The aggregated potential benefits to NASA were derived from the sum total of the potential savings in each trip distance category.

Of the six trip distance categories, those trips ranging from 400-599 miles (round trip) accounted for the largest percentage of individual trips, 22.6 percent.

Based upon the U.S. Travel Data Center Survey for 1974, trips in this category averaged approximately 249.2 miles (one way) and 2.73 overnight stays while on business. Estimating the per mile cost of such a trip to be 16¢/mile, the cost of the average business trip which occurs most frequently is:

| | |
|--------------|------------------------------------|
| \$ 79.74 | long-haul transportation |
| 70.98 | ground transportation |
| <u>95.55</u> | subsistence (lodging, food, misc.) |
| \$246.27 | Total |

Included in the trip distance category of 2000 or more miles is foreign travel, which accounts for approximately 5 percent of the total business trips. The costs associated with business traveling abroad are generally higher due to money exchanges, more costly travel expenditures, etc. The additional expenses incurred as a result of such travel have not been included here, thus making the costs and benefits here conservatively based upon domestic travel expenditures.

PRELIMINARY NASA BENEFITS BY TRIP DISTANCE CATEGORIES

| | <u>MILES</u> | <u>TRUE TRAVEL COSTS - (TRIP COSTS + TELECONFERENCING COSTS) = BENEFITS</u> | | |
|-------------------|--------------|---|------|--------------------------------|
| | (round trip) | MILLION \$ | | |
| j = 1 (200-299) | | 3.9 | 2.8 | .4 |
| 2 (300-399) | | 6.3 | 4.6 | .6 |
| 3 (400-599) | | 13.8 | 10.3 | 1.3 |
| 4 (600-999) | | 13.9 | 10.6 | 1.2 |
| 5 (1000-1999) | | 15.9 | 12.4 | 1.3 |
| 6 (2000 +) | | 31.5 | 25.8 | 2.1 |
| | | | | <u>3.6</u> |
| | | | | TOTAL POTENTIAL BENEFITS |
| | | | | \$11.9 |

C-2

ERDA VIDEO TELECONFERENCING SERVICE (EVCS)¹

ERDA is the first federal agency to have an operational audio/video teleconferencing service. The service is the leased ATT Picturephone Meeting Service, which is basically a 2-way audio/video interconnection between Germantown, Maryland and downtown Washington, D.C.

Each conference room consists of a special table which accommodates up to 6 active participants with facilities for an additional 10-20 observers. The rooms have voice-activated cameras which detect and transmit the image of the participant speaking. A graphics camera for transmitting slides, viewgraphs or hand drawings and a tripod-mounted camera for easel presentations are also in each conference room. Hard copy material is available within 10-12 seconds of viewing on the monitor or through conventional facsimile. Additional audio conferencing is also available in order to add other conference locations on an audio-only basis. Taping of audio and/or video transmission is also possible.

The ERDA Video Conferencing Service has been in operation since February 1976. During the first 15 months of service, it was estimated that approximately 10,464 man-hours of travel time were saved by substituting a teleconference for a three-hour commute between Maryland and downtown Washington. The system has been able to save travel expenditures in the first nine months which were equal to the capital investment to start the service.

¹Private communication with Charles Brasheares, Assistant Director of Telecommunications, ERDA, June 29, 1977.

THE ERDA VIDEO CONFERENCING SERVICE (EVCS)

- ERDA IS THE FIRST GOVERNMENT AGENCY TO HAVE AN OPERATIONAL AUDIO/VIDEO CONFERENCING SERVICE--ERDA VIDEO CONFERENCING SERVICE
- THE SYSTEM CURRENTLY LINKS GERMANTOWN, MARYLAND FACILITIES WITH DOWNTOWN WASHINGTON, D.C. OFFICES WITH AN EXPANSION OF SERVICES TO CHICAGO EXPECTED DURING THE COMING YEAR.
- SERVICES INCLUDE FULL DUPLEX AUDIO AND VIDEO, FACSIMILE, BLACK/WHITE VIDEO, VIEW GRAPHS, AND FULLY AUTOMATIC OPERATION.
- DURING FEBRUARY 1976 - JUNE 1977:

3488 INDIVIDUAL CONFEREES PARTICIPATED
AVERAGED 5-6 CONFEREES PER MEETING
APPROXIMATELY 10,464 TRAVEL HOURS SAVED.

EVCS COSTS AND BENEFITS¹

The EVCS was evaluated internally by ERDA for savings based upon manpower travel hours. During the first 15 months of service, approximately 6,976 conference participants took part in the program. Half of these people (3488) saved about three hours of travel time between Germantown, Maryland and Washington, D.C. Based upon an average hourly wage of \$13/hour, a benefit of \$136,032 in direct salary expenses was realized. Including overhead costs² into these benefits, the realized benefits of the service during the first 15 months of operation were nearly \$200,000.

The travel type substituted by this service is local (<200 miles) and would encompass only a small percentage of the total of ERDA's travel, thus, the potential magnitude of an overall agency teleconferencing service benefits is great. Currently, an expansion of the service to the Lamont, Illinois facilities is being planned contingent upon new tariff schedules.

¹Private communication with Charles Brasheares, Assistant Director of Telecommunications, ERDA, June 29, 1977.

²An estimate of 132 percent was used.

EVCS COSTS AND BENEFITS

FEBRUARY 1976 - JUNE 1977

| | |
|-----------------|---|
| 3,488 | USERS--ONE HOUR AVERAGE CONFERENCE* |
| <u>x3</u> | HOURS--TRAVEL SAVED EACH CONFERENCE |
| 10,464 | TOTAL TRAVEL HOURS SAVED |
| <u>x\$13</u> | AVERAGE HOURLY WAGE RATE |
| \$136,032 | |
| | |
| \$315,594 | TRAVEL COSTS AVOIDED (INCLUDING OVERHEAD) |
| <u>-115,600</u> | EVCS LEASE COSTS TO DATE |
| \$199,994 | TOTAL SAVINGS TO DATE (6/77) |

*Total Conferees 6,976.

EVCS FACILITY AND SERVICE COSTS¹

Physical plant capital costs, long-term liability security costs and monthly transmission costs are the expenditures incurred by the ECVS. An initial capital investment is needed to equip the teleconference room(s) and install the AT&T equipment. Security capital is also necessary for the rental of line and room equipment. Monthly room and line expenses are for a 24-hour day, 7-day week, private line connection. Monthly transmission expenses for the facility are in the amount of approximately \$30 per working week hour (160 hours per working month).

The ERDA initial capital investment was \$97,500 plus a liability fund of \$221,200 which was required for the equipment rental.

¹Private communication with Charles Brasheares, Assistant Director of Telecommunications, ERDA, June 29, 1977.

EVCS FACILITY AND SERVICE COSTS

GERMANTOWN MARYLAND - WASHINGTON, D.C.:

| | |
|--|-------------|
| 2 ROOM OUTFITTED | \$ 60,000 |
| ROOM EQUIPMENT RENTAL LOCAL 5-YEAR TERM LIABILITY | 46,700 |
| LINE EQUIPMENT 10-YEAR TERM LIABILITY | 174,500 |
| AT&T INSTALLATION | 37,500 |
| MONTHLY ROOM AND LINE EXPENSE (2 ROOMS) | 4,800/month |

CHICAGO FACILITY:

| | |
|------------------------------|-------------|
| 2 ROOMS OUTFITTED | \$ 30,000 |
| ONE-TIME INSTALLATION CHARGE | 50,000 |
| 5-YEAR TERM LIABILITY | 56,000 |
| MONTHLY EXPENSE (2 ROOMS) | 2,940/month |

GENERALIZATION OF POTENTIAL ANNUAL BENEFITS TO ERDA

NASA and ERDA are similar agencies in their type of work and the general organization under which the agencies operate. Both agencies devote large percentages of their budgets to research and development work which is often contracted to industrial contractors outside the federal agency. The methodology and the assumptions used to derive NASA's potential cost-savings as a result of teleconferencing have therefore been applied to ERDA.

ERDA's travel budget of \$15 million annually was used as the basis for the cost-savings model. Assuming the same average cost of \$309 per trip, ERDA personnel took about 48,540 business trips annually. Based upon the substitutability of an audio plus facsimile system, ERDA could potentially save \$10 million annually. Given that ERDA currently has a two node operational video teleconferencing service (ECVS) which has proved to be very successful the potential cost-savings of expanding this ECVS agency-wide could only increase the potential cost-savings beyond \$10 million annually.

It should be noted that the cost-savings for ECVS which has been previously noted at about \$200,000 for 15 months represent teleconference substitution for a very small percentage of the total business trips taken by ERDA personnel.

In addition to the potential cost-savings from in-house travel expenditures, 1 percent of the total procurement dollar volume for industrial contracts was assumed to be for travel expenditures between the contractor and agency personnel. This percentage was derived from a survey of 60 NASA hardware and nonhardware contracts.¹

¹ From correspondence with Mark Gielecki, Applications Systems Analysis Office, GSFC and discussions with various NASA contractors.

GENERALIZATION OF POTENTIAL ANNUAL BENEFITS TO ERDA

| | <u>NASA</u> | <u>ERDA</u> |
|---|-------------|-------------|
| | (MILLIONS) | (MILLIONS) |
| TOTAL BUDGET * | \$4053 | \$7000 |
| IN-HOUSE TRAVEL EXPENDITURES | 18 | 15 |
| ESTIMATED CONTRACT ** TRAVEL EXPENDITURES | 11 | 22 |
| POTENTIAL ANNUAL SAVINGS FROM AUDIO TELECONFERENCING | 12 | 10 |

* BASED ON 1978 APPENDIX OMB BUDGET.

** ASSUMING ALL CONTRACTORS WOULD HAVE TELECONFERENCING
CAPABILITY.

GENERALIZATION OF POTENTIAL BENEFITS TO OTHER CIVILIAN GOVERNMENT AGENCIES

A further extrapolation of potential cost-savings based upon annual in-house travel expenditures was then applied to other civilian federal agencies. Benefits range from approximately \$9 million annually for the Veteran's Administration to \$52 million annually for HEW.

Though NASA and ERDA are agencies which are quite similar in their methods of operation and have travel expenditures which are comparable, the other civilian agencies examined in this preliminary study (HEW, VA, GSA, DOT) differ in composition and mode of operation from NASA and ERDA. Consequently, without further study the benefit estimates for those other civilian agencies must be viewed with decreased confidence.

GENERALIZATION OF POTENTIAL BENEFITS TO OTHER CIVILIAN GOVERNMENT AGENCIES
(\$ MILLIONS)

| AGENCY | IN-HOUSE TRAVEL EXPENDITURES | CONTRACT TRAVEL EXPENDITURES | POTENTIAL BENEFITS FROM TELECONFERENCING | | |
|------------------------|---------------------------------|---------------------------------|--|-----------|--------|
| | | | IN-HOUSE | CONTRACTS | TOTAL |
| NASA | \$ 18 (.4%)* | \$29 | \$11.9 | \$10.6 | \$22.5 |
| ERDA | 15 (.2%) | 60 | 9.9 | 22.2 | 32.1 |
| HEW | 90 (.05%) | 33 | 40.5 | 12.4 | 52.9 |
| VA | 20 (.1%) | -- | 9.0 | -- | 9.0 |
| GSA | 13 (.3%) | -- | 5.9 | -- | 5.9 |
| DOT | 101** (.6%) | 1 | 45.0 | 0.5 | 45.5 |
| STATE OF CALIFORNIA | 28*** | -- | 14.6 | -- | 14.6 |

* Percentage of total 1978 budget as proposed to Congress.

** Includes U.S. Coast Guard training expenses.

*** 1974 Governor's Budget, state communications agency estimates that 52% of travel expenditures could be foregone with teleconferencing.

POTENTIAL MILITARY AND DEFENSE-RELATED COST SAVING BENEFITS

In the following pages of this section, the benefits are estimated which might result from the use of teleconferencing in lieu of certain types of travel by those parts of the Air Force, Army, Navy and other defense agencies engaged in research, development, testing and evaluation (RDT&E). To accomplish this, the benefit model developed and utilized to extrapolate the potential savings for civilian agencies is used for military business travel in RDT&E operations. In order to use NASA experience as a model, the teleconferencing system for these defense activities is limited to audio-plus-facsimile communications. The percentage increase of teleconferencing substitutability as a function of added video and computer-to-computer capabilities has not been considered. Although it is believed that the military agencies have experience with video teleconferencing systems, it was not possible to obtain factual information on those applications.

As a result, all of the potential cost savings developed here are based upon audio-plus-facsimile capabilities. These are assumed to be conservative estimates of potential savings.

Programs in support of research, development, testing and evaluation of new and improved weapon systems and related equipment are performed by the Army, Navy, Air Force, and other DOD activities. Such programs provide research and development through contracts to industry, contractors, government laboratories, universities, and nonprofit organizations. The 1977 estimated RDT&E obligations were approximately \$11.6 billion (including reimbursable expenditures). The facing page outlines these expenses by military organizations. RDT&E is approximately 10-11 percent of the total DOD budget of \$108 billion (1977 estimate).

Defense Agency research for 1977 was approximately \$653 million, of which \$400 million was appropriated to the three largest agencies within Defense. These agencies are National Security Agency (NAS), Defense Nuclear Agency (DNA) and Defense Advanced Research Projects Agency (DARPA). There exist government laboratories within these agencies which do in-house and contracting of defense RDT&E. For other military agencies, much work done within the Defense Agency RDT&E program is contracted to private business.

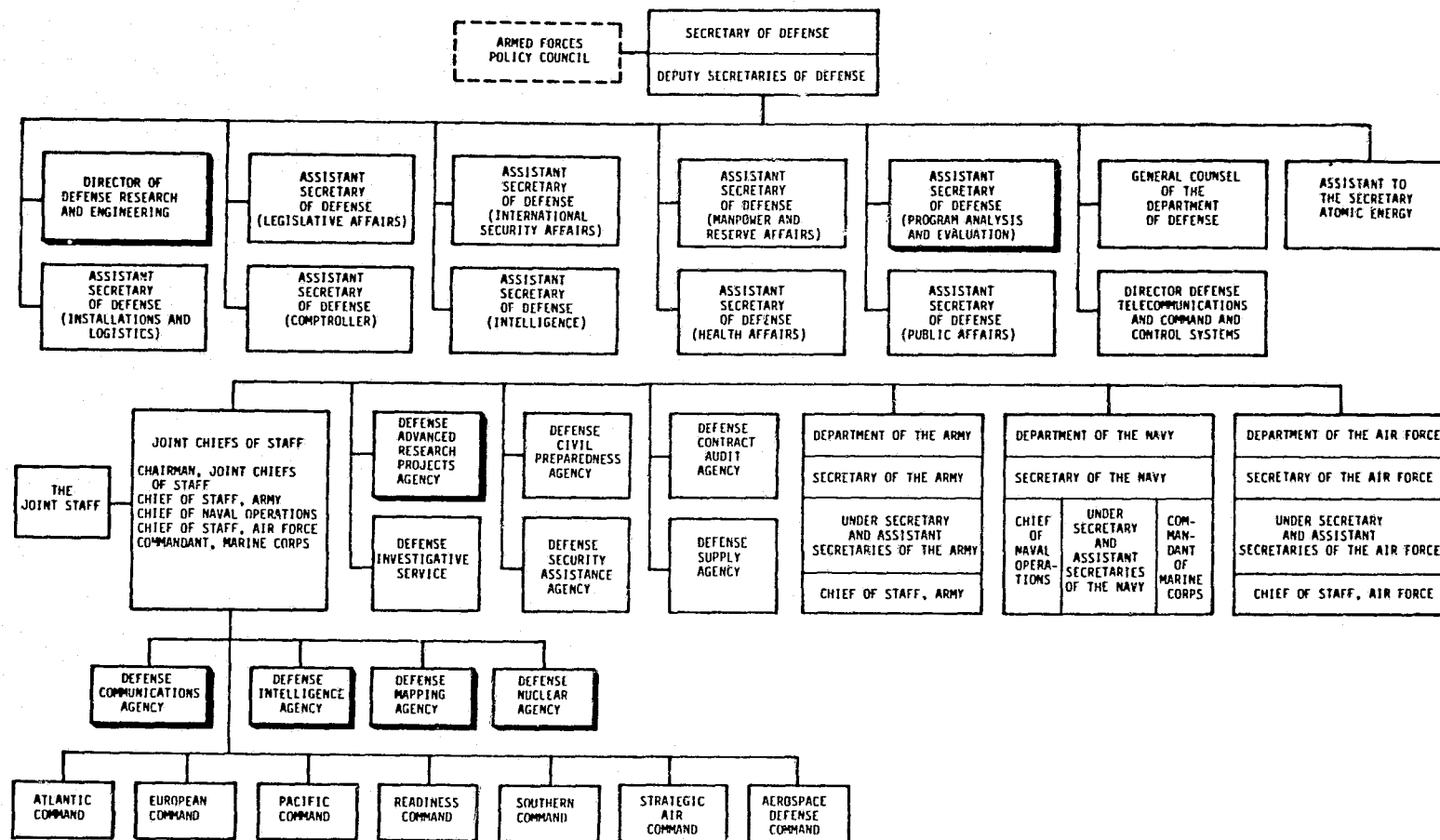
The following pages illustrate the organization of the defense agencies included in this estimate. Those parts of the defense organization shown with the heavy outline are believed to be similar in method of operations to NASA for the conduct of RDT&E.

NATIONAL DEFENSE RDT&E EXPENDITURES¹

| | <u>1977 ESTIMATED \$ MILLIONS</u> | |
|---------------------|---------------------------------------|-------|
| ARMY | \$ 2687 | |
| NAVY | 3927 | |
| AIR FORCE | 4335 | |
| DEFENSE AGENCIES | 653 | |
| DIRECTOR OF DEFENSE | <u>30</u> | |
| | \$11632 | TOTAL |

¹ OMB Budget, Appendix for Fiscal Year 1978.

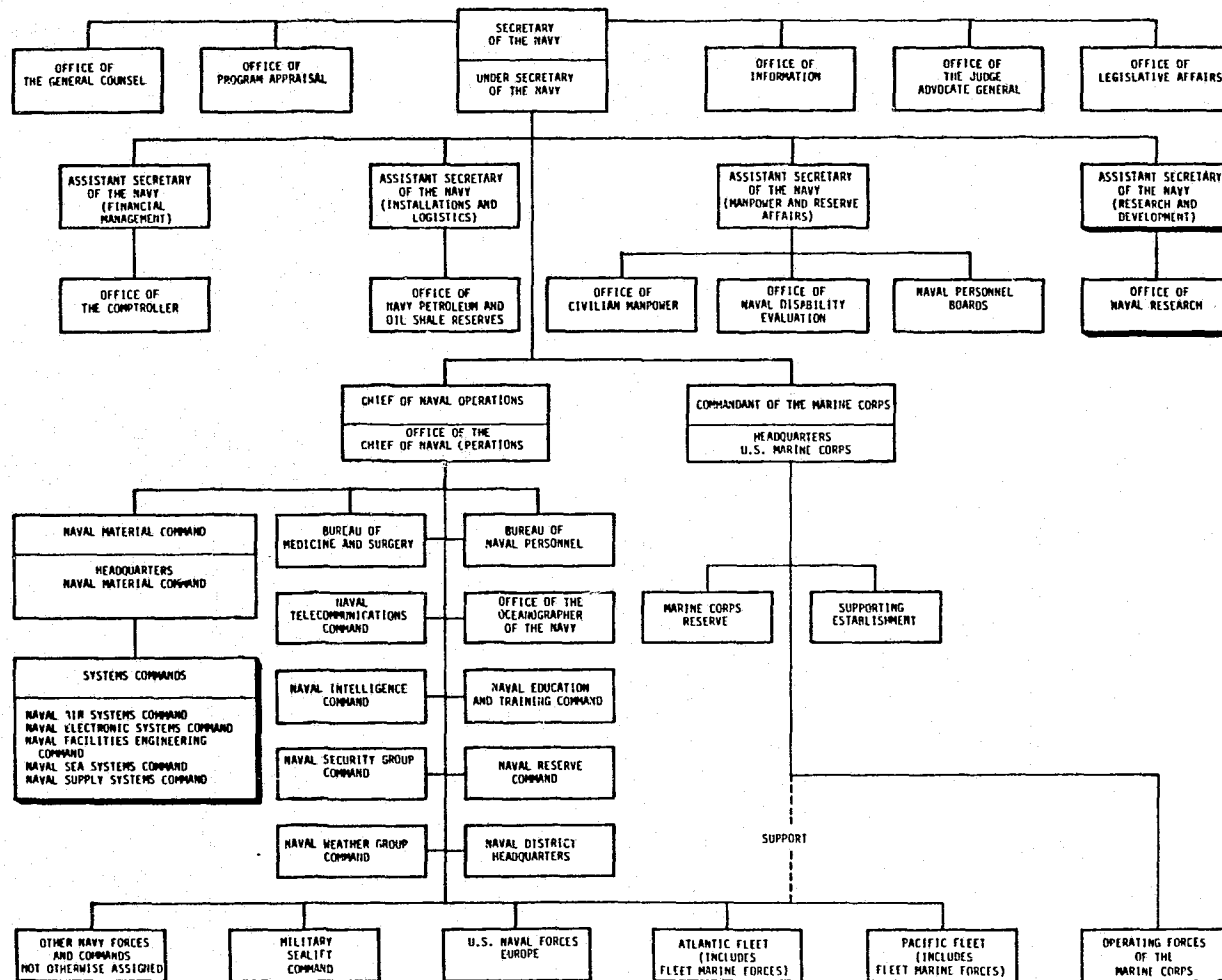
DEPARTMENT OF DEFENSE



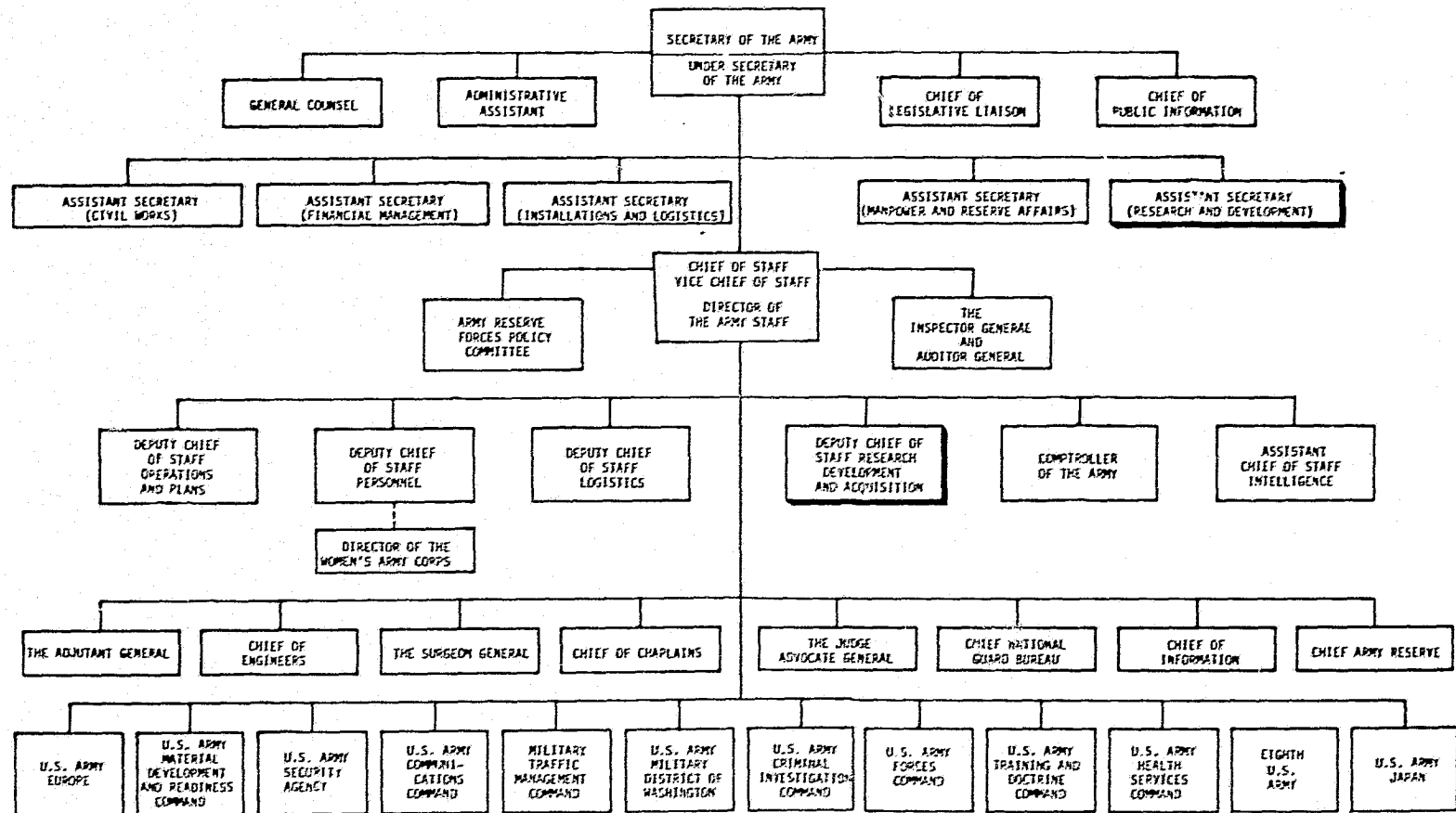
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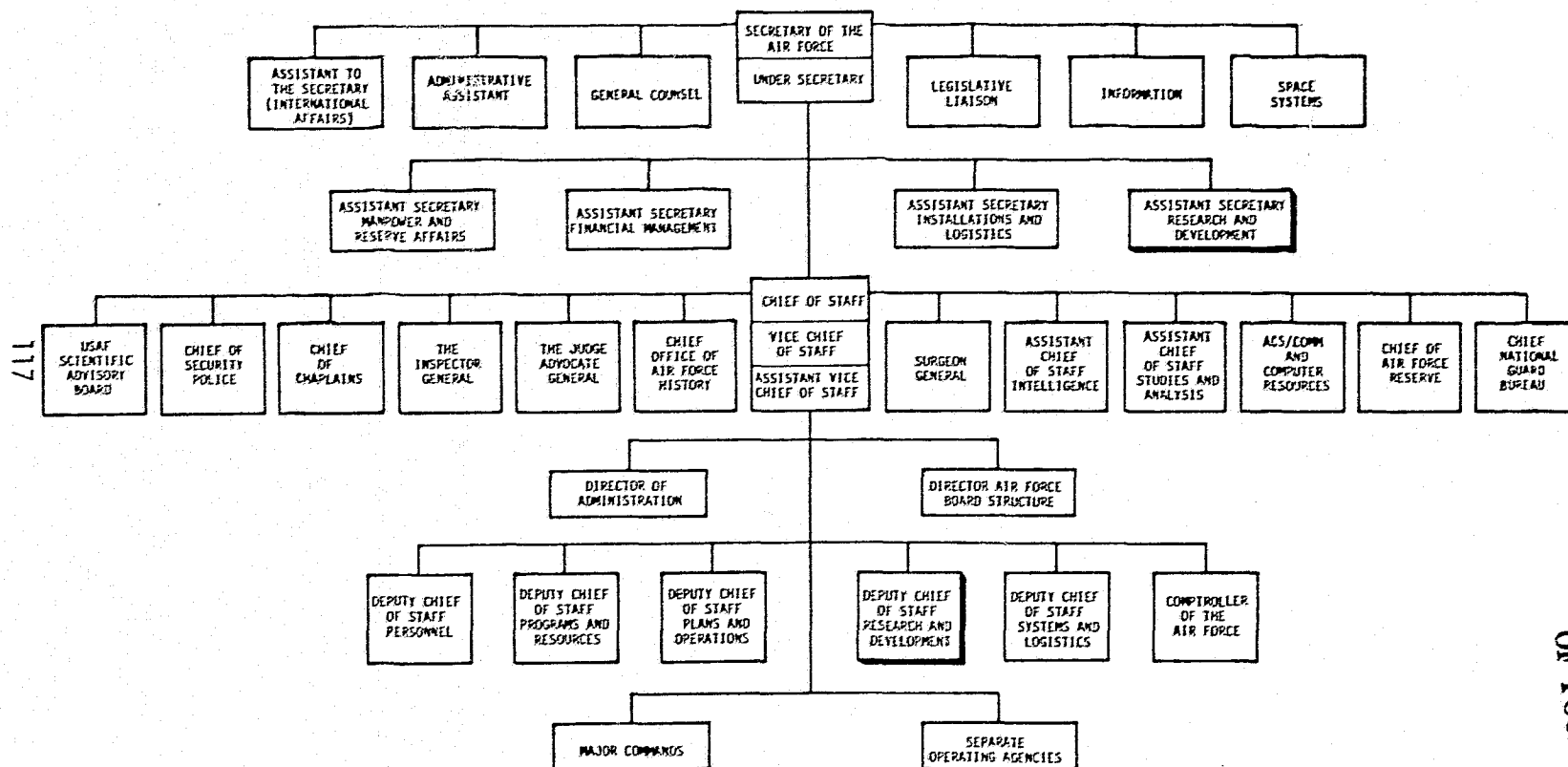
DEPARTMENT OF THE NAVY



DEPARTMENT OF THE ARMY



DEPARTMENT OF THE AIR FORCE



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SUMMARY OF NAVY RDT&E TRAVEL BUDGET AND APPROPRIATIONS

During the 1977 fiscal year, an estimated \$4 billion will be spent on Naval RDT&E. Of this, approximately \$12 million will be spent in transportation of civilian and military personnel.

The average trip cost is about \$1000 with the majority of trips related to project management (90% of total trips). The three trip categories provided on the facing page do not correspond to the trip categories in the ECON model.

The overall figures, therefore, as obtained from the Navy Controller's Office, have been adjusted to absorb the 0.5 percent of training-related trips, and reflect the 3-4 percent of overall business trips for technical and scientific meetings. Therefore, the data used as model input is as follows:¹

| | <u>Percentage of Total Business Trips</u> | | <u>Adjusted Percentage of Business Trips</u> |
|----------------|---|---|--|
| Project | 90% | } reflecting 3-4% technical meetings | 89% |
| Administrative | 9.4% | | 7.4% |
| Training | .5% | | |
| Meetings | | | 3.1% |

¹Totals do not add to 100% due to rounding.

SUMMARY OF NAVY RDT&E TRAVEL
BUDGET AND APPROPRIATIONS

| <u>TRIP EXPENDITURES:</u> | <u>FY 1977</u> <u>\$ THOUSANDS</u> | <u>FY 1978</u> <u>\$ THOUSANDS</u> | <u>FY 1979 (ESTIMATE)</u> <u>\$ THOUSANDS</u> |
|---------------------------|---------------------------------------|---------------------------------------|--|
| MILITARY PERSONNEL | | | |
| PER DIEM | 1499 | 1761 | 1981 |
| TRANSPORTATION | 1952 | 2284 | 2634 |
| CIVILIAN PERSONNEL | | | |
| PER DIEM | 3935 | 4521 | 4965 |
| TRANSPORTATION | <u>4393</u> | <u>5033</u> | <u>5593</u> |
| TOTAL | \$11779 | \$13599 | \$15173 |

| <u>TRIP PURPOSE:</u> | | <u>NUMBER OF TRIPS</u> | |
|----------------------|--------------|------------------------|--------------|
| TRAINING | 61 | 62 | 64 |
| ADMINISTRATIVE | 1105 | 1288 | 1334 |
| PROJECT MANAGEMENT | <u>10618</u> | <u>12254</u> | <u>13760</u> |
| | 11784 | 13604 | 15158 |

POTENTIAL COST SAVINGS BENEFITS TO NAVY RDT&E

Potential cost savings benefits are derived in a manner similar to the previous civilian section. The significant averages employed by the model are as follows:

Average wage rate = \$14.40/hr.

Overhead rate = 100%

Total number of trips = 11784

Average cost per trip = \$1000

Rate of Substitutability
for teleconferencing = $1 - \sum_i \left(\frac{k_i}{100} * F_i / 100 \right) = .583$

The facing page outlines the preliminary potential cost savings as developed for the ECON model. Potentially \$6.1 million could be saved in transportation, manhour and overhead costs related to Navy RDT&E work. This is approximately 1.5 percent of the total RDT&E appropriation for the Navy.

PRELIMINARY POTENTIAL COST SAVING BENEFITS TO NAVY RDT&E

| MILES (ROUND TRIP) | TRUE TRAVEL COST | - | (COST OF TELECONFERENCING | + | UNSUBSTITUTABLE TRAVEL COSTS | = | BENEFIT |
|-----------------------|------------------------|---|------------------------------|---|---------------------------------|---|----------------|
| 1 (200-299) | 777359 | - | (89232 | + | 453166) | = | \$235000 |
| 2 (300-399) | 1245072 | | 141281 | | 725836 | | 378000 |
| 3 (400-599) | 2737787 | | 283343 | | 1596079 | | 858400 |
| 4 (600-999) | 2756421 | | 267910 | | 606981 | | 1881600 |
| 5 (1000-1999) | 3168222 | | 287707 | | 1847061 | | 1033500 |
| 6 (2000 +) | 5207577 | | 465178 | | 3035972 | | <u>1706400</u> |

\$6,092,900 TOTAL

SUMMARY OF POTENTIAL COST SAVINGS

In the absence of comparable data for the Air Force and Army to that provided by the Navy, simple ratios have been used to estimate the potential benefits for these defense activities. As shown on the opposite page, the estimated cost savings from the use of audio and facsimile teleconferencing by those agencies which appear to fit the NASA model for the conduct of RTD&E is estimated to be approximately \$127 million per year. It should be noted that this is the potential benefit of a limited capability teleconferencing system, utilizing only audio and facsimile transmission. It is apparent that substantial benefits may be obtained through the implementation of teleconferencing systems within the federal government. However, further studies are needed to determine the optimum form of these systems, and the relationship between system costs and benefits. Moreover, it is urged that studies be performed with the cooperation of the client agencies in order to substantiate the estimated benefits.

SUMMARY OF POTENTIAL COST SAVINGS
(\$ MILLIONS)

| <u>AGENCY</u> | <u>TRAVEL EXPENDITURES 1977 EST.</u> | <u>POTENTIAL COST SAVINGS OF TELECONFERENCING</u> | | |
|-------------------|--|---|------------------|--------------|
| | | <u>IN-HOUSE</u> | <u>CONTRACTS</u> | <u>TOTAL</u> |
| NASA | 18 | 13.6 | 12.1 | 25.7 |
| ERDA | 15 | 11.3 | 25.5 | 36.8 |
| NAVY (RDT&E) | 12 | 6.8 | -- | 6.8 |
| ARMY (RDT&E) | 29 | 16.6 | -- | 16.6 |
| AIR FORCE (RDT&E) | 32 | 18.3 | -- | 18.3 |
| DEFENSE AGENCIES | 4 | 2.3 | -- | <u>2.3</u> |
| TOTAL | | | | \$127.2 |

* Cost savings are based upon 1976 dollars.

STUDY RESEARCH AND CONTACTS

During the course of this project, numerous agencies, businesses and individuals were contacted in order to gain insight into the current teleconferencing state-of-the-art, operational systems, travel patterns and expenditures within the scope of this study.

The following pages enumerate these references and personal contacts. The lack of availability of data from some military agencies is a constraint on the overall comprehensiveness of the estimated benefits to the military. Only the Navy provided the travel and expenditures data necessary for our benefit model. A generalization was therefore utilized to develop benefits for the other military agencies, based upon the data and model results for the Navy.

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DEFENSE NUCLEAR AGENCY

OSD CONTROLLER'S OFFICE

NATIONAL SECURITY AGENCY

DEFENSE ADVANCED RESEARCH PROJECTS AGENCY

OAS NAVY

OAS ARMY

OMB

2.3 DATA TRANSFER AND EDUCATIONAL APPLICATIONS

2.3.1 SATELLITE TELECOMMUNICATIONS AND
CONTINUING LEGAL EDUCATION (CLE)

INTRODUCTION

The legal profession appears to have continuing educational requirements and activities which depend almost exclusively on the spoken and written word, both of which can be effectively conveyed by existing telecommunication practice.

If satellite telecommunications are to be an effective adjunct to continuing legal education (CLE) they must be adapted to the complex national CLE structure that exists today, and as it may develop in the future.

Historically, CLE has been an intrinsic element of the legal profession through the apprenticeship of young lawyers to established law firms. In recent years, a fundamental change has occurred in CLE. State CLE organizations have been created which are manned and directed by qualified nonpracticing lawyers dedicated fulltime to CLE. On the other hand, federal-national CLE organizations, the oldest and largest of which is the Practicing Law Institute (PLI), have been in existence since 1933.

The majority of CLE organizations belong to the Association of Continuing Legal Education Administration (ACLEA) whose recent membership identifies 43 state organizations and a total of 65 CLE organizations. At this time, however, the organization members of ACLEA are not all at the same stage of development.

Many professional, societal and governmental pressures have brought about CLE's progressive development. Today, for example, about 6 percent of the national bar is faced with a cyclic recertification program and an additional 20 percent with specialization or designation programs. To these mandatory programs the bar itself proposes many alternatives.

Overall, the objectives of CLE are to sustain for the public the concept of lawyer competence, access to competent legal services and reasonable costs for these services. To this end, ACLEA in 1975 published its "Standards of Operation for Continuing Legal Organization." In particular, those standards establish that CLE organizations should not be operated for private profit.

While it is difficult to visualize the trends in CLE with clarity, CLE's future seems to be one of expansion in response to lawyers' education, competitive maintenance and measurement, direction of the bar, dissemination of the legal impact of legislation to lawyers and to the discernment and control of technology in the practice of law and the operation of the law office. To successfully support these trends, CLE it seems, must expand economically to encompass a maximum of the legal profession.

STATISTICS OF THE LEGAL PROFESSION

The 1970 lawyer population was 355,242.¹ The estimated 1975 lawyer population, according to the ABA, was 425,039 distributed amongst the states, as shown in Appendix B. The American Bar Foundation will begin a new statistical study in 1978. The current student lawyer population is about 125,000.² By the early 1980s there could be about 550,000 lawyers.

Legal practice may be subdivided as being concerned with state legal matters and federal-national legal matters.² The Statistical Abstract of the United States locates lawyers in relation to population. It is assumed that lawyers located in cities with populations in excess of 0.25 million are most likely to be primarily concerned with federal-national legal matters. About 51.6 percent of the national bar falls in this category. The remainder, 48.4 percent, is likely to be concerned with state legal matters. It is estimated that, in 1970, the federal-national lawyer population was concentrated in 56 centers and the other lawyers in 7,026 centers of population.

About 300 major law firms exist nationally, each employing from 50-100 lawyers. It is estimated that there are approximately 80,000 law firms with an average of 5.5 lawyers per law firm. Many law firms are, however, one-person operations and some lawyers, to make a living, combine law with real estate or some other activity.³

Lawyer incomes do not seem to be statistically reported. However, the national legal receipts for 1972 were \$10.938 billion.¹ Using the 1970 lawyer statistics, this indicates that the average receipts per lawyer are about \$30,790 per annum and it can be reasonably conjectured that during the period 1970-72 the average lawyer's income was \$15,395. If lawyer income kept pace with inflation, the average 1977 income may be on the order of \$23,361 (taking into account the change in the size of the bar). The states with significant lawyer populations--New York, California, Illinois and Pennsylvania--provide lawyer average incomes in excess of the average by 6 to 23 percent. In 1950 the Gross Legal Product was \$1.3 billion; in 1966, \$4 billion; and in 1974, \$12 billion, approximately a factor of 10 increase in 24 years.⁴ Corporate law firm salaries may range from \$45,000 for a lawyer to \$64,000 for a partner per annum on the average. Senior partners may earn annually in the range from \$100,000 to \$250,000.

The range of variation of lawyer incomes is quite large (on the order of 25 to 1). This income variability must be considered when attempting to extend CLE to as wide a population as possible.

¹ Statistical Abstract of the United States, 1976.

² The Economist, November 5, 1977.

³ Private communication with J.A. Robertson, Associate Director, Practicing Law Institute, New York.

⁴ New York Times Magazine, November 20, 1977.

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STATISTICS OF THE LEGAL PROFESSION

| <u>PRIMARY PRACTICE</u> | <u>LAWYER POPULATION</u> | <u>CONCENTRATION (SITES)</u> |
|-----------------------------|------------------------------|----------------------------------|
| FEDERAL-NATIONAL | 219,209 | 56 |
| STATE | 205,830 | 7026 |

POPULATION VARIATION: { 500 WYOMING
64,000 NEW YORK

AVERAGE INCOME: \$23,361/YEAR

NUMBER OF STUDENTS: 125,000

CHARACTERISTICS OF CONTINUING LEGAL EDUCATION (CLE)

CLE organizations are well aware of the characteristics of the populations that they seek to serve. In general CLE professional activities are delivered by legal notables free of charge. Course accessibility in time and space is sought to the maximum degree possible with conscientious consideration to minimizing the time away from practice. Because of the scale of the CLE operations, this is easier for state CLE than for federal-national CLE. State CLE is made available during the evening hours and on Saturday mornings. National CLE cannot be as liberal, and a major constraint is to have live discussion available at any CLE presentation. The subject matter at the national level requires expert lecturers whose time and travel must of necessity be restricted.

State CLE events cost participants from \$35 to \$90, including course materials, for a typical 4-hour session.¹ However, in New Jersey one course was priced at \$1,000 per attendee.¹ It was concerned with medicine and law, presented as a special video tape with a medical lecturer. Break-even requirements at the state level are quite modest, perhaps 7 attendees.¹ National program fees range from \$25 to \$500 with the majority priced from \$160 to \$200 for a 1.5- to 2-day session. Some national courses extend over one week.²

Course materials include books, papers and pamphlets, cassette recordings and, in recent years, studio-quality color video tapes.

The same materials are common to state and national-federal CLE. Early tapes cost \$40,000 to produce but learning has reduced production costs to about \$15,000.² Live tutorials are today considered to be a necessary accompaniment to video tape for maximum appeal and success.

National programs have already noted attendance increases from states with mandatory CLE and from interested non-lawyers. These latter attendees are less constrained in budgetary allocations for CLE.

Some states, such as Mississippi, where ETV is a well-organized system, are considering it as a CLE distribution mechanism.³ National organizations have briefly investigated satellite delivery but consider it to be too expensive.² However, both national and state CLE organizations can see potential advantages in satellite delivery.^{1,2}

¹ Private communication with H.H. Kestin, Institute of Continuing Legal Education, Newark, New Jersey.

² Private communication with J.A. Robertson, Associate Director, Practicing Law Institute, New York.

³ Private communication with M.D. Cook, Director, Institute of Continuing Legal Education, University of Mississippi Law School, Mississippi.

CHARACTERISTICS OF CONTINUING LEGAL EDUCATION (CLE)

- NONPROFIT
- ACTIVE 44 YEARS
- ABOUT 65 ORGANIZATIONS UNDER ACLEA
- 4 ORGANIZATIONS RESPOND TO FEDERAL-NATIONAL; 43 TO STATE NEEDS
- STRUCTURED TO LAWYER DENSITY, MAXIMUM ACCESSIBILITY, MINIMUM TIME FROM PRACTICE
- LECTURERS ARE PRACTICING LAWYERS WHO DONATE TIME
- CLE REACHES ABOUT 11% OF POPULATION FOR FEDERAL-NATIONAL, 30% STATE
- COURSE COSTS ABOUT \$150-\$200 FEDERAL-NATIONAL; ABOUT \$50 STATE
- PROFESSIONAL CONCERNS: COMPETENCE, EDUCATION, MANDATORY QUALIFICATIONS
- CLE FREQUENTLY USES STUDIO-QUALITY COLOR TV TAPES
- RESPONSIVE TO POSSIBLE USE OF SATELLITE COMMUNICATIONS

CLE SATELLITE EXPERIMENTS AND COMMUNICATIONS EXPERIMENTS

A full description of the experiment at the Hastings School of Law, San Francisco, California on January 29, 1977, is provided in Appendix C.¹ Apart from some technical difficulties in one down link from CTS, the experiment was reasonably successful technically, financially and educationally. Financial success would have been to recover program expenses from the fees of participants. This goal was impeded because of CTS programming which did not allow sufficient time for complete publicity. Those responsible for this program were of the opinion that the 550 lawyers attending the experiment was considerably in excess of the number who would normally attend at Hastings. Lawyers are reluctant, at least in California, to travel more than 125 miles to a CLE meeting.²

The Moot Court experiment is also fully described in Appendix C. Strictly speaking, this was an experiment in legal education rather than CLE, yet its success and acceptance by the legal fraternity has implications for CLE.³

The American Law Institute in Philadelphia has experimented with the terrestrial distribution of CLE video tapes to law offices in Philadelphia, an experiment judged by ALI not to have been successful.⁴

¹ P.E. Rush, "An Education Report on the Communications Satellite Broadcast of 'The Best of Trial Advocacy 1977,'" ETO, University of California, Berkeley.

² Private communication with P.E. Rush and M. Francisco, Educational TV Office, University of California, Berkeley.

³ Private communications with Professor A. Hornstein, University of Maryland Law School and S. Tishler, Maryland Center for Public Broadcasting.

⁴ Private communication with P.A. Wolkin, Executive Director, ALI-ABA Committee on Continuing Professional Education, Philadelphia, Penn.

CLE SATELLITE EXPERIMENTS AND COMMUNICATIONS EXPERIMENTS

- HASTINGS SCHOOL OF LAW, BERKELEY, CALIFORNIA, NATIONAL SCHOOL OF TRAIL ADVOCACY--USING CTS. REASONABLY SUCCESSFUL.
- MOOT COURT FOR STUDENT TRAINING, MARYLAND SCHOOL OF LAW, USING CTS AND SITES PROVIDED BY WESTINGHOUSE AT LIMA, OHIO AND BALTIMORE, MARYLAND. PARTICIPANTS CONSIDERED IT IMPRESSIVE.
- TERRESTRIAL DISTRIBUTION OF TV TAPED PROGRAMS TO LAW OFFICES IN PHILADELPHIA.

FEDERAL-NATIONAL CLE (PLI OPERATION)

PLI is the nation's oldest professional organization involved with CLE. Organized in 1933, it has been very active since about 1943. Their major CLE concern is with federal-national CLE delivery, primarily directed to maintaining and advancing lawyer competence that results from new statutes, decisions, regulations and developments in the social and economic climate, although their courses attract many not in legal practice. PLI also publishes specialized law books, about 130 new titles in 1976, of which 115 were provided in conjunction with CLE programs. As a consequence they distributed 160,000 books.¹

The national scale of their operation and a fundamental constraint on their delivery restricted them in 1976 to an access of about 11 percent² of their lawyer population. The fundamental constraint on delivery is that the PLI "faculty" is constructed from practicing lawyers who give their time free of charge and that attendees seek the presence of this live expertise at the seminars.

The presentation of topics is therefore restricted to a small number of sites for each topic. The facing chart indicates that each topic was presented at the most at two different sites in 1976, and considerable travel is associated with attendance as is indicated below.¹

| <u>Site</u> | <u>Out-of-State Attendance</u> |
|-------------------|--------------------------------|
| New York City, NY | 60% |
| California | 49% |
| Chicago | 74% |

In midsummer 1976, PLI produced their first video program, "Impact of Taxes on Matrimonial Agreements," the course content of which was viewed nationwide by about 1,800 lawyers in groups of from 20 to 600, so-called general practitioners. This tape is a teaching-type presentation which uses a moderator rather than a "faculty" member. The use of studio-quality color video tapes by PLI is expanding, with four additional tapes destined for use in 1977.

It seems reasonable to attempt to analyze the extended use of a satellite distribution system for federal-national CLE with the intent simply of extending the number of presentations and, hence, the accessibility of PLI's program.

The initial step is to determine the annual operating costs of PLI which will be assumed to remain constant. Any incremental costs must then be recoverable from incremental revenue.

¹ Practicing Law Institute, Annual Report 1976.

² Private communication with J.A. Robertson, Associate Director, Practicing Law Institute, New York.

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FEDERAL-NATIONAL CLE (PLI OPERATION)

| | |
|--|----------------|
| CURRENT PROGRAMS OFFERED (TOPICS) | 151 |
| NUMBER OF PRESENTATIONS | 257 |
| AVERAGE COURSE COST | \$200 |
| POPULATION SERVICED | 25,000 |
| POPULATION ACTIVE | 219,209 |
| ANNUAL REVENUES | \$5 MILLION |
| SITE RENTALS \$0.339 MILLION | |
| TEAM EXPENSES \$0.19 MILLION (FACULTY) | |
| PLI OPERATING COSTS | \$4.47 MILLION |

FEDERAL-NATIONAL CLE SATELLITE OPERATION

The federal-national lawyer population is assumed to be concentrated at 56 sites throughout the nation, as the statistical information indicated. Each site is then assumed to receive 151 topics annually. It is assumed, in accordance with trends, that each topic can be supplied as a telecommunicable form such as TV, possibly with some voice feedback or perhaps simply using an on-site moderator of the programs provided. With delivery at each of the 56 sites, almost all of the population is assumed to have a realistic opportunity to participate in the CLE.

Maintaining the current course cost at \$200, the system annual revenue, less operating expenses, would be \$35.14 million. The incremental expenses associated with the system are estimated to be \$17.86 million under the assumptions indicated.

Each topic (seminar) is assumed to have a duration of 2.42 days. Thus, the presentation of 151 topics requires a full year to deliver (i.e., communicate), and would therefore fully utilize one transponder, assuming the delivery was a video program. The space segment rental is, therefore, for 4 transponders, one for each time zone. The total ground investment for the 56 sites is \$1.18 million. Viewing facilities rental at each site is estimated at \$545 per day.

It is additionally assumed that each of the population serviced would attend just one topic presentation, that is, an attendance per lawyer of about 20 hours. Then at each site for each topic about 23 attendees will appear. The facilities rental cost per day per attendee is approximately \$24.

FEDERAL-NATIONAL CLE SATELLITE OPERATIONS

| | |
|------------------------------------|------------------------|
| PROGRAMS OFFERED (TOPICS) | 151 |
| NUMBER OF PRESENTATIONS 151 x 56 | 8,456 |
| AVERAGE COURSE COST | \$200 |
| POPULATION SERVICED | 198,055 |
| POPULATION ACTIVE | 219,209 |
| ANNUAL REVENUE | \$39.61 MILLION |
| ANNUAL REVENUE LESS OPERATING COST | <u>\$35.14</u> MILLION |

INCREMENTAL EXPENSES

| | |
|---|------------------------|
| SITE RENTALS 8456 x \$1319 | \$11.15 MILLION |
| SPACE SEGMENT RENTAL 4 x \$1.6 MILLION | \$ 6.4 MILLION |
| COSTS OF INVESTMENT PER SITE (5 YEARS, 10%) | \$ 0.31 MILLION |
| ANTENNA, ETC. \$20,000/SITE | |
| TV RECEIVER \$ 1,000/SITE | |
| TOTAL INVESTMENT \$1.18 MILLION | <u>\$17.86</u> MILLION |

IMPACT OF SATELLITE USE ON FEDERAL-NATIONAL CLE COSTS AND COVERAGE

There is an estimated net savings of \$17.28 million from the postulated system operation which could reduce each attendee's course cost by \$87.25 or 43.6 percent (from \$200 to \$112.75). These savings tend to be the maximum possible that would result from the adoption by every state of a requirement for mandatory CLE.

The postulated system, a system of maximum CLE opportunity, services about 90 percent of the market population. A reduction of the serviced population by 86,400 to a serviced population of 51 percent of the market population would nullify the indicated savings of this system of maximum opportunity.

Today the current system services only about 11 percent of the market population and the 151 topics are presented a total of 257 times and distributed over 19 locations throughout the nation. Presenting each topic at each of these 19 locations to the current 25,000 serviced population would result in a deficit of \$9.77 million, with the current \$200 cost for each course. To offset this deficit, the attending population would have to increase from 11.4 percent to 33.7 percent of the market population. Such an increase would, in the absence of any mandatory CLE requirements, have to result from the enhanced opportunity for CLE attendance.

IMPACT OF SATELLITE USE ON FEDERAL-NATIONAL CLE COSTS AND COVERAGE

| | |
|---|-----------------|
| ANNUAL NET REVENUE - INCREMENTAL EXPENSES | \$17.28 MILLION |
| EXCESS REVENUE/POPULATION | \$87.25 |
| COURSE PRICE REDUCTION % | 43.6 |

∴ A LARGE-SCALE SATELLITE DELIVERY TO A MAXIMUM POPULATION SUCH AS MIGHT RESULT FROM MANDATORY CLE NATIONWIDE COULD PRODUCE AN ANNUAL COST SAVINGS OF \$17.28 MILLION FOR THE ACTIVE NATIONAL-FEDERAL LAWYER POPULATION.

FEDERAL-NATIONAL CLE, OTHER SATELLITE USES

The maximum opportunity CLE system allows about 2.5 days for each topic duration and delivery. Topic delivery today requires a range of from 1.5 days to 2.5 days. Alternate use (during working hours) of communication channel rental time with no increase in cost is possible if courses were delivered in evening hours or during the weekend.

This excess time available from the system could be organized to perform other associated federal-national CLE operations which would themselves permit operating cost savings. These cost savings would reduce the incremental serviced population requirements. For example, the estimated mailing costs¹ saved are equivalent to the course fees obtained from 12,000 attendees at the current course costs, about 5 percent of the market population, or 21,286 attendees at the reduced course costs of the system, about 10 percent of the market population.

Presentation site rentals represent a substantial part of the incremental costs. It is possible that sites could be made available at the premises of a group of major law firms who might be willing to trade occasional space for communication services of interest.

Interactive communication amongst lawyers relating to professional activities may require assured privacy, such as is obtainable from scrambling. A scrambler for TV, such as is being currently developed by Westinghouse, could cost, in small quantities, from \$2000 to \$3000. Rental of these scramblers is being considered for applications in SBS, however, but the rental fee is not known.²

¹Practicing Law Institute, Annual Report, 1976.

²H. B. Shutterly, "Secure Television Systems for Satellite Communication Links," Westinghouse R&D Center, Pittsburgh, Pennsylvania; and private communications with H. B. Shutterly and H. Nunnally, Manager, Small Terminal Application Program, Westinghouse.

FEDERAL-NATIONAL CLE, OTHER SATELLITE USES

- MAILING BROCHURES AND INVOICES, ABOUT \$2.4 MILLION ANNUALLY
- BOOK DISTRIBUTION CURRENTLY 160,000 ANNUALLY--POSSIBLE INCREASE TO 1.2 MILLION
- INTERACTIVE CONSULTATION AMONGST LAWYERS
- COMMON BRIEF PREPARATION, ETC.
- REMOTE TRIAL REPRESENTATION
- OTHER NATIONAL CLE ORGANIZATIONS COULD ACCESS SYSTEMS

CLE CONCLUSIONS

A federal-national CLE system using satellite communications to maximize opportunity of access would produce a cost savings of \$17 million per year if the total appropriate legal population attended the courses given. Since the proposed system provides ease of access it is necessary to determine the dependence of attendance on access, without nationwide mandatory CLE. Statistics suggest today that only about 15000 lawyers, or 7 percent of the market, can separate themselves for 3 1/2 to 5 days from their practices.

Cost savings assume an increase in the current use of color video tape. While these tapes could be replicated and physically distributed, only communications could respond to the additional demanded presence of legal expertise with the tape presentation. State CLE use of satellite communications requires further study because of individual state needs and alternatives for delivery. CLE could have a societal impact, producing social benefits whose influence would be far reaching if CLE opportunity was maximized. It is estimated that 1977's gross legal product was about \$17.2 billion. Assuming \$8.6 billion was overhead costs, a 1-percent improvement in efficiency through universal CLE could produce a social benefit of \$86 million annually.

CLE CONCLUSIONS

- COST SAVINGS TO THE LEGAL PROFESSION FROM A FEDERAL-NATIONAL CLE SYSTEM PROVIDING UNIVERSAL AND MAXIMUM ACCESS TO CLE THROUGH SATELLITE COMMUNICATIONS ARE ESTIMATED TO BE \$17 MILLION PER YEAR AS A MAXIMUM.
- ACTUAL ANNUAL COST SAVINGS WILL DEPEND ON THE GROWTH OF MANDATORY CLE PROGRAMS OR ON THE ATTRACTION OF INCREASED ACCESS TO CLE PROGRAMS.
- CURRENTLY ONLY ABOUT 15,000 LAWYERS, OR 7 PERCENT OF THE FEDERAL-NATIONAL LAWYER MARKET, ARE ABLE TO SEPARATE THEMSELVES FROM THEIR PRACTICES FOR 3 1/2 TO 5 DAYS TO ATTEND COURSES.
- INITIAL SATELLITE EXPERIMENTS APPEAR TO HAVE BEEN SUCCESSFUL IN PROVIDING LAWYER NEEDS, REMOTELY.
- SATELLITE COMMUNICATIONS APPLIED TO STATE CLE REQUIRES FURTHER INVESTIGATION.
- EFFECTIVE CLE PROGRAMS PRODUCING EFFICIENCY IN LEGAL PRACTICE COULD GENERATE SOCIAL BENEFITS. A 1-PERCENT IMPROVEMENT IN EFFICIENCY IS ESTIMATED TO PRODUCE AN \$86 MILLION ANNUAL SOCIAL BENEFIT IN REDUCED COSTS TO SOCIETY.

2.3.2 SOME POTENTIAL ECONOMIC COST SAVINGS AND SOCIAL
BENEFITS ASSOCIATED WITH SATELLITE DATA TRANSFER
COMMUNICATIONS IN PUBLIC SERVICE, IN 1980-1985

INTRODUCTION

Data is produced continually by public and private sources. Data transfer deals with the technological processes of conversion to digital form of data and the telecommunications connectivities required to transport data from its origin to its destination. The data is digitalized for the telecommunications transmissions so as to achieve appropriate transmission fidelity.

In public service, the data/information may consist of two basic types. The first usage corresponds to the transformation of data to produce pertinent information, as in accounting, statistical generation or management information. The second usage employs data so as to effect or change some public service activity (for example, communication of information to the classroom may bring about changes in the education system). Communication connectivity provides the mechanism for bringing about change in public service activities. Controversy can arise amongst those responsible for a public service concerning the effectiveness of communication connectivity in bringing about change. As a consequence, many public service data transfer uses remain in limbo awaiting both the establishment and the acceptance of the effectiveness of enhanced communication connectivity.

The concept of communication connectivity in public service can be extensively developed as a systematic procedure which liberalizes national embedded resources to make them accessible, without constraint, to all the nation's public. In principle, the communication connectivity allows a digitalized or computerized representation of a resource to be telecommunicated to any potential user. This expands the social utility of the resource. Also, it formally allows the interaction between user and resource through the existence of the communication connectivity. The availability of enhanced communications connectivity not only affects existing public service applications but may lead to concept changes within other applications which thence increase the demand for communications connectivity.

The motivation for utilizing communications is generally twofold: the improvement of the public service itself and the reduction of cost or the improvement of efficiency in providing the public service. These motivations are not necessarily independent.

Data connectivities can evidently be provided by many forms of telecommunications technology. The forms likely to prevail in public services are those priced consistent with budgetary allocations which respond to the social utility provided. In general, in public service, the connectivity price should be a minimum determined by the capacity to pay of the public service communities having a common interest.

Public service financing is provided by diverse mechanisms, such as federal grants, local taxation, public subscriptions and tax-exempt foundation grants, some part of which is already spent for telecommunications activity. The amount of activity depends on the characteristics of the particular public service. If a satellite connectivity substitutes for an existing telecommunications link, it is likely to be favored if it is less expensive. If a satellite connectivity provides a new potential of public service utility that is effective, efficient and necessary, its cost must be related to the utility provided through the connectivity. In general, it is clear that the evaluation of the potential utility is difficult. The satellite connectivity then provides an opportunity for potential utility realization and this opportunity is greatest if the cost is as low as technology can provide.

Since the concept is that satellite connectivities will provide public services that are both effective and efficient, in the long term the public service should (in theory) be able to pay for the service from its collective budget. In the short term, during which evaluation of the opportunity is to be determined, an experimental or research phase, uncertainty in the outcome of the evaluation implies supplementary budgeting.

As a specific technology, space communications may offer certain advantages. For some applications, the technology appears to offer technical and functional connectivity at the lowest price. In addition, it offers connectivities whose price is largely independent of connectivity distance. In essence, it is a technological connectivity form least likely to interfere with the requirements of public service. As for any other form of connectivity technology, its price of connectivity service arises from a relationship between the connectivity capacity available and the statistics of its utilization by its users during the effective lifetime of the capacity. As a connectivity technology, it requires, as do all other forms, a terminal or coupling service specialized to the technology and the application.

This section describes the potential connectivity cost savings in public services compared to terrestrial technology; an example of constraint on satellite connectivity use as it relates to aggregation of the market or the community of common interest and two examples of the use of improved communication connectivity in public service applications. Advantages and constraints are presented as dollar values.

DATA TRANSFER IN PUBLIC SERVICE

Data transfer is a result of interaction through communication connectivities amongst remote data terminals and communicating computers, using digital data streams. Data terminals are classified as dumb, smart or intelligent according to the programming available to the user at the terminal. This available programming is used to relieve the central processor or computer of many message and housekeeping functions necessary to the processor. The cost of "intelligence" is declining and the trend is therefore to intelligent terminals.

Computers, appropriate to data transfer, are varied. There are extra large to small mainframe computers, minicomputers, microcomputers and microprocessors. Current trends, made available by large-scale integration (LSI) of electronic functions, favor expansion of smaller physical computers with lower prices.

Connectivity is provided by the terrestrial voice network, the terrestrial digital networks, the valued-added tariffed packet switched terrestrial networks and, by 1980, by the Satellite Business System (SBS) as well as currently operating domestic satellites, and private microwave special carriers.

DATA TRANSFER IN PUBLIC SERVICE

INTERACTIONS AMONGST DATA TERMINALS AND COMPUTERS

TERMINAL to TERMINAL

TERMINAL to COMPUTER

COMPUTER to COMPUTER

AS COMPLETELY DIGITAL DATA STREAMS FOR PUBLIC SERVICE
APPLICATIONS

ECONOMIC BENEFITS OF DATA TRANSFER IN PUBLIC SERVICE

Potential economic benefits of data transfer in public service can arise from many applications, but few have been experimented with to a degree that can identify them as universally acceptable to those responsible for public services.

Examples illustrative of the potential for public service have been selected and cost savings have been developed for these examples.

The examples treat the principal elements of potential application of public service data transfer. The first example evaluates the totality of all potential applications. The second example uses a typical potential national application of computer based education (CBE) to show that constraints on user aggregation may also influence the realization of potential benefits as well as the acceptance of CBE as an educational technique by the nation's educators.

Two examples of potential benefits that could arise from concepts of the utilization of data transfer in the national framework are discussed. These concepts are pertinent to current national problems and their solutions, although as yet unconsidered by public service in the form presented. The form presented, however, has some realism in the framework of development of data transfer use, currently, by public service providers.

ECONOMIC BENEFITS OF DATA TRANSFER IN PUBLIC SERVICE

POTENTIAL SOURCES OF ECONOMIC BENEFITS:

- CONNECTIVITY COST REDUCTION USING SATELLITES
- CONNECTIVITY COST REDUCTION AS AN INFLUENCE ON PUBLIC SERVICE MARKET AGGREGATION
- EXTENSION OF SOCIAL UTILITY OF DATA OR INFORMATION RESOURCE

DATA TRANSFER APPLICATIONS INVESTIGATED

The four examples of data transfer potential economic benefits to be investigated in this preliminary analysis are identified on the facing page.

The preliminary analyses develop results in cost savings tentatively appropriate to the years beyond the 1982-85 time frame when an operational Public Service Communication Satellite System may be available.

Since the time at which such cost savings may emerge in activity cannot be identified due to many subtle dependencies, benefits cannot actually be identified. For this reason, only tentative annual cost savings that may be realizable in the future are identified.

DATA TRANSFER APPLICATIONS INVESTIGATED

- DATA NETWORK CONNECTIVITY COST SAVINGS
- NATIONAL COMPUTER BASED EDUCATION (CBE, CAI)
- DATA TRANSFER FOR DROPOUT PREVENTION
- DATA TRANSFER AND MEDICAL HISTORIES

THE CURRENT STATUS AND GROWTH ESTIMATES FOR DATA TRANSFER HARDWARE

Data transfer in public service must be viewed against a background of the national general utilization of data transfer, because there are few technical specializations that distinguish public and private service applications, and because private usage will influence public service usage. These influences will be largely determinants of the prices of connectivities and of the equipment necessary for utilization of data transfer applications. The public service market is identified primarily as a submarket of the national market. Further influence is expected on acceptable data transfer applications in public services as private services explore and develop techniques appropriate to private sector data transfer applications and concepts. In addition, there is a global or international aspect of influence which extends the concepts of data transfer to international resources, and which could influence national concepts by international standardization.

The opposite chart summarizes the estimated quantities of terminals and computers by type used in data transfer application.

THE CURRENT STATUS AND GROWTH ESTIMATES FOR DATA TRANSFER HARDWARE

REMOTE DATA TERMINALS

| INSTALLED | | ANNUAL GROWTH | |
|-----------|-------------|-------------------|--|
| 1967 | 1977 | 1977 - 1980 | 1978 - 1981 |
| 50000 | 1.5M - 2.5M | * 0.325M - 0.574M | INTELLIGENT 23% COMPOUNDED DUMB 7% COMPOUNDED |

COMPUTERS INSTALLED

| | 1976 | 1980 | GENERAL PURPOSE COMPUTERS IN PUBLIC SERVICE, % (1976) | |
|--------------------|--------|-------|--|------|
| MEDIUM - LARGE | 0.088M | | EDUCATION | 5.7 |
| MINI | 0.132M | 0.75M | STATE, LOCAL GOV'T | 5.7 |
| | | | FEDERAL GOV'T | 3.4 |
| MICRO | | | MEDICAL & HEALTH | 2.7 |
| MICRO PROCESSORS } | 0.74 M | 10.0M | UTILITIES | 1.6 |
| | | | | 19.1 |

NATIONAL DATA TRANSFER (ALL ACTIVITIES) 1980 - 1985

BANDWIDTH: 0.32 Gbps to 6.04 Gbps (VARIOUS SOURCES)

REVENUE: FACTOR OF FOUR GROWTH IN REVENUE 1975-1980 (ATT),
\$5 BILLION TO \$22 BILLION ANNUALLY***

* SCIENCE, VOLUME 195, NO. 4283, MARCH 18, 1977, p. 1174.

** IBID., p. 1096-1102.

*** IBID., p. 1174.

NATIONAL DATA TRANSFER SYSTEMS CHARACTERISTICS

Many current networks for data transfer are extant, almost all of which use the telephone network for connectivity.

Some special networks are identified which deal with packet switched data (arising from the Arpanet concept), a data-ordering procedure that maximizes capacity use.

The Satellite Business System will be an operational satellite system by 1980 (FCC approval exists, although there are problems unresolved with FTC and the Justice Department). Some of its known or planned characteristics are detailed.

An indication is given of the large global network extant for data transfer. The United States will be a participant. Many of these networks are organized for public service containing private service as a special case for access, control and security.

NATIONAL DATA TRANSFER SYSTEMS CHARACTERISTICS

TERRESTRIAL

- ATT DATAPHONE SWITCHED DIGITAL SERVICE (56 Kbps)
- ATT TRANSACTION NETWORK SERVICE
- TELENET TARIFFED VALUE-ADDED COMMON CARRIER PACKET SWITCHED
- DATACOM TARIFFED VALUE-ADDED COMMON CARRIER PACKET SWITCHED
- ABOUT 17 U.S. GOVERNMENT AGENCY NETWORKS OPERATING OR PLANNED
- VAST ARRAY OF PRIVATE NETWORKS AND SPECIAL CARRIERS
- GLOBAL BY 1978, 250 LARGE NETWORKS EACH WITH ABOUT 2000 TERMINALS

SATELLITE

| | | |
|-----------------------------------|---|----------------------------|
| <u>SATELLITE BUSINESS SYSTEMS</u> | - | 1980 - 375 EARTH STATIONS |
| (SERVICE TO 48 STATES) | | 1986 - 7500 EARTH STATIONS |

| | | |
|--------------------|---------------|---------------|
| <u>INVESTMENT:</u> | SPACE SEGMENT | \$117 MILLION |
| | EARTH SEGMENT | \$176 MILLION |
| | DEVELOPMENT | \$ 96 MILLION |

| | |
|------------------|-------------------------|
| <u>CHANNELS:</u> | 70000 (30 - 1200 bps) |
| | 18000 (1200 - 9600 bps) |
| | 3000 (>9600 bps) |

NATIONAL DATA TRANSFER TARIFFS

Current data transfer costs for terrestrial systems of packet switched delivery are difficult to compose into a single tariff, because of their specialization. Two current United States networks are TELENET and DATACOM. Their tariffs are shown on the facing page.

The tariff for DATAPAC, a Canadian packet switched network, is also shown on the facing page for the charges additional to that of connectivity and because it includes added cost if international protocol is not adhered to. It is to be expected that this protocol will become effective in systems operating in the United States.

NATIONAL DATA TRANSFER TARIFFS

TELENET*

- \$2.00 - \$5.00 PER CHANNEL HOUR, PACKET 100 bps

DATACOM**

- \$1.70 PER KILOPACKET 6 a.m. - 8 p.m. } NETWORK 4800 bps,
\$0.85 PER KILOPACKET NIGHT } PACKET OF 132
CHARACTERS

ACCESS REQUIRES MICROPROCESSOR (\$2000 COST OR \$100/MONTH
FOR 1-YEAR LEASE)

DATAPAC***
(CANADA)

- \$0.32 TO \$0.93 PER KILOPACKET (FUNCTION OF DISTANCE)

PACKET 256 CHARACTERS

WITHOUT SNAP**** ADDED COST \$0.25 PER KILOPACKET

HOST ACCESS CHARGE \$417.50/MONTH 9600 bps
\$ 60.00/MONTH 300 bps

IMMEDIATE PRIORITY ADD 25%

* INTERNATIONAL TELECOMMUNICATIONS, AUGUST 1976, p. 30.

** COMPUTER WORLD, JULY 18, 1977, p. 23.

*** COMPUTER WORLD, JULY 4, 1977, p. 25.

**** SNAP - STANDARD NETWORK ACCESS PROTOCOL ESTABLISHED IN CONFORMITY WITH
CCITT GROUP VII PROTOCOL X .25 AS INTERNATIONAL STANDARD

EXPERIMENTS IN SATELLITE DATA TRANSFER IN PUBLIC SERVICE

A number of experiments in satellite data transfer for public service have been undertaken. The efforts in satellite computer-based education were plagued by technical and nontechnical difficulties, some of which involved interconnection with ATT telephone network.

Research use of the ALOHA system by Pacific Educational Computer Network has not been implemented for reasons not known. This refers to the specific use of the ALOHA system for research investigations into data transfer for education and not of ALOHA for other applications.

The experiments with CTS and libraries have yet to take place. The University of Illinois electronic blackboard experiment has not yet taken place.

So far, most activity in satellite data transfer has been quite tentative, and has not provided a clear evaluation of accomplishment. Thus, there is as yet no experimental data upon which to base the estimates of potential economic benefits for future operational systems.

EXPERIMENTS IN SATELLITE DATA
TRANSFER IN PUBLIC SERVICE

SATELLITE COMPUTER-BASED EDUCATION

- STANFORD UNIVERSITY, ATS-3, INDIAN ISLETA PUEBLO (NEW MEXICO)
- WAMI, ATS-6, OHIO STATE UNIVERSITY
- VETERANS ADMINISTRATION AND ATS-6

RESEARCH - COMPUTER INTERLINK

- 1968 UNIVERSITY OF HAWAII SYSTEM ALOHA USING ATS-1 TO NASA-AMES
- 1973 SYSTEM EXTENDED TO INCLUDE UNIVERSITY OF ALASKA
- 1973 SYSTEM PLANNED FOR USE IN PACIFIC EDUCATIONAL COMPUTER NETWORK

LIBRARY

- LISTER HILL AND ATS-1, LISTER HILL AND CTS
- SATELLITE LIBRARY INFORMATION NETWORK (SALINET) WITH CTS
- NEW YORK STATE UNIVERSITY AND CTS

EXPERIMENTAL

- UNIVERSITY OF ILLINOIS TO EXPERIMENT WITH DIGITIZED TELEWRITER OR ELECTRONIC BLACKBOARD CONCEPT.

GENERALIZED PUBLIC SERVICE SATELLITE CONNECTIVITY COST SAVINGS IN DATA TRANSFER

It is proposed to establish a reasonable interconnectable structure of communicating data terminals and computers and to demonstrate the connectivity cost reductions a satellite system could produce from such a structure for public service use.

In 1970 the number of United States computers was $380/10^6$ population. In 1977 it is estimated to be $1000/10^6$ population. In the future, 70 percent of computers will communicate. Conservatively, it is assumed that 70 percent of the difference between the computers installed in 1970 and those installed today are communicating, that is, $434/10^6$ population. In 1982, the communicating computer population would be 98,952 and 100,000 will be assumed.

Today there are between 1.5 and 2 million remote terminals. During the next five years or so, manufacturers indicate a growth factor of 2.5 to 3.7 so that by 1982 they expect between 3.8 million and 7.4 million terminals. Datran projected about 2.5 million by 1980 with a growth of about 0.5 million every two years, to project about 3 million terminals by 1982. A reasonable estimate of 4 million communicating terminals in 1982 is assumed.

Data transfer will not all occur at the same bit rate. A representative distribution of bit rates was determined versus percentage of users using the bit rate, according to terminal type, to give a weighted mean of 9548 bps and a standard deviation of 7900 bps or 83 percent of the mean.

Using the structure and a network of connectivity to satisfy its average needs, resulted in a national data transfer requirement in 1982 of (5.969 ± 4.938) Gbps. If repeats are necessary to accommodate transmission errors, the requirement would be for (7.440 ± 6.155) Gbps. Because error control methods are many and varied, the basic estimate will be used in the cost savings development.

| GENERALIZED PUBLIC SERVICE SATELLITE CONNECTIVITY COST SAVINGS IN DATA TRANSFER | | |
|--|---|---|
| SYSTEM CHARACTERISTIC | | BASIS FOR ASSUMPTION |
| STRUCTURE | 10^5 COMMUNICATING COMPUTERS | 1976 2.2×10^5 COMPUTERS, 40% MEDIUM OR LARGE 60% MINI 7.5×10^5 MICROPROCESSORS OR MICROCOMPUTERS |
| | 4×10^6 DATA TERMINALS | 1 FOR 50 URBAN POPULATION $\rightarrow 4 \times 10^6$ 1 FOR 500 RURAL POPULATION $\rightarrow 1 \times 10^5$ |
| TRANSFER 8-HOUR DAY | PUBLIC SERVICE (20%): 1194 Mbps LONG DISTANCE (35%): 418 Mbps | NOMINAL TRANSFER: 5969 Mbps TRANSFER UNCERTAINTY: $\pm 83\%$ |
| CURRENT TRANSFER COSTS | AVERAGE COST: \$3.50/CHANNEL HOUR AVERAGE COST DISTRIBUTION: <u>EQUIPMENT</u> <u>CONNECTIVITY</u> * \$1.225 \$2.275 | TELENET PACKET SWITCH TARIFFS EQUIPMENT:CONNECTIVITY, 35%:65% AVERAGE OF A NUMBER OF SYSTEMS |
| SATELLITE OPERATING 8-HOUR DAY | AVERAGE SATELLITE CHANNEL DATA RATE: 9600bps NO. OF CHANNELS: 4.4×10^4 | TO TRANSFER 418 Mbps IN LONG DISTANCE PUBLIC SERVICE |

* TELECOMMUNICATIONS (EURO GLOBAL), VOLUME 10, NO. 6, JUNE 1976, p. 50-51.

ESTIMATED APPLICATIONS OF DATA TRANSFER IN PUBLIC SERVICE

Public service data transfer is estimated to be about 20 percent of the nominal total load, or 1194 Mbps. Of this, according to transmission statistics, about 35 percent will be in long distance data transfer, and is a likely candidate for cost savings when transmitted by satellite. The data transfer of concern is 418 Mbps. With an average channel transfer rate of 9600 bps, 4.4×10^4 channels must be provided. It is noted that assuming a data transfer rate of 35 Mbps per transponder, the public service estimated demand could be provided by a 12 transponder satellite.

An estimate has been made of application areas and their corresponding data transfer requirements in Mbps. This estimate concentrates on public service requirements, not only those most likely to be long-distance requirements which would benefit most from satellite connectivities.

It is to be expected that many applications could be new. Examples of new applications are presented later in this section.

ESTIMATED APPLICATIONS OF DATA TRANSFER IN PUBLIC SERVICE

| <u>APPLICATIONS</u> | <u>Mbps</u> |
|-------------------------------|-------------|
| PRIMARY & SECONDARY EDUCATION | 35 |
| HIGHER EDUCATION | 40 |
| LIBRARY INTERACTIONS | 50 |
| BIOMEDICAL | 10 |
| GENERAL RESEARCH | 10 |
| GENERAL HEALTH CARE | 20 |
| PUBLIC BROADCASTING | 5 |
| VALUE TRANSFER | 50 |
| SECURITIES AND EXCHANGE | 30 |
| GENERAL COMPUTER | 20 |
| HIGH-SPEED COMPUTER | 100 |
| GOVERNMENT (FEDERAL) | 50 |
| GOVERNMENT (STATE) | 30 |
| LAW ENFORCEMENT & JUDICIAL | 60 |
| CITIZEN DISASTER & EMERGENCY | 10 |
| POLITICAL INTERACTIONS | 10 |
| ELECTRONIC MAIL | 25 |
| NEWSPAPERS | 15 |
| PUBLISHING | 20 |
| | <u>590*</u> |

* THIS LIST DOES NOT ADD UP TO THE NOMINAL ESTIMATE OF PUBLIC SERVICE REQUIREMENT OF 1194 Mbps. IT DOES FALL IN THE RANGE OF UNCERTAINTY 203 Mbps - 2185 Mbps.

DATA NETWORK ESTIMATED CONNECTIVITY COST SAVINGS

The terrestrial service cost for data transfer is assumed to be those of Telenet, i.e., an average of \$3.50 per channel hour, selected because it is the simplest tariff structure. From evaluation of a number of typical configurations it is assumed to be representative of terrestrial service, if 35 percent of the terrestrial cost is for equipment and 65 percent for the connectivity. Thus, the terrestrial connectivity cost is assumed to be \$2.275 per channel hour. Each 1% of terrestrial connectivity cost savings will produce an annual savings of \$2.98 million ($0.02275 \times 4.1 \times 10^4 \times 8 \times 260$, for eight hours per day and 260 days per year).

It is assumed that a 50% reduction of such costs is reasonable using satellite connectivities, to estimate cost savings. Satellite connectivity cost reduction, compared to the terrestrial costs assumed, for public service data transfer demand is estimated to be a nominal value of \$104 million per year with a possible range from \$18 million per year to \$190 million per year.

Nominally, this cost savings could be associated with the start of PSCS operations in 1982 yet it is unlikely that all public service data transfer uses will be in force at that time even if a satellite dedicated to public service is then available. The estimated savings is likely to be accumulated in partial sums over a considerable interval of time, in a manner that is not expected to be uniform with time. The characteristics of the form of accumulation of the partial sums cannot be specified without further study and experiment, so that an economic benefit cannot be estimated at the present time.

DATA NETWORK ESTIMATED CONNECTIVITY COST SAVINGS

| | |
|---|-----------------------------------|
| TRANSFER (8-HOUR DAY) | 418 Mbps |
| SATELLITE CHANNELS | 4.4×10^4 |
| CURRENT TERRESTRIAL CONNECTIVITY COST | \$2.275/CHANNEL HOUR |
| CONNECTIVITY COST REDUCTION FOR 1% REDUCTION IN COST | \$2.08 MILLION/YEAR |
| CONNECTIVITY COST REDUCTION 50% REDUCTION IN COST | \$104 MILLION/YEAR (NOMINAL) |
| UNCERTAINTY RANGE | \$18 MILLION - \$190 MILLION/YEAR |
| INFLUENCES ON DEMAND RESULTING FROM REDUCTION FROM \$3.50 to \$2.63 PER SYSTEM CHANNEL HOUR NOT ESTIMATED. | |

A TYPICAL NATIONAL DATA TRANSFER NETWORK FOR COMPUTER-BASED EDUCATION

Various forms of computer-based education are being considered and assessed by educators with two basic considerations in mind. It is thought to be worthwhile to the education process to provide educational tools which can allow students to independently study and it is thought that this form of education may increase educational productivity. Thus, productivity improvement is considered possible employing technology that will tend to shift education from being labor intensive to capital intensive, but such a shift is not seen as being educationally effective by all educators.

This analysis is based on a simple experimental structure in current use by Educom for Computer-Aided Instruction (CAI) and data retrieval for students at Dartmouth, MIT and SUNY. Telenet packet switched connectivity is involved.

System costs are illustrated in the facing page. The system cost is a variable dependent on the system configuration, and the minimum configuration cost will be used throughout this analysis; the remote data terminal cost is variable depending on the terminal complexity.

The experimental process could be replicated throughout the nation's 110,000 schools and colleges, an estimated total of 2.5 million classrooms, where each classroom would have a single data terminal transferring 5×10^4 bits per hour. Thus, the national system would require the transfer of 35 Mbps and use packet switching.

It is assumed that the connectivity for such a system could be provided by satellite to reduce system costs. The space segment appropriate to the task would be shared amongst all classrooms and each school would require a ground terminal to interface with the satellite for direct delivery to these classrooms.

The satellite communication system is assumed to employ simple scheduling for its packet switching so that only about 16 percent of connectivity capacity is throughput. Thus, the satellite capacity required is $35/0.16$ or 220 Mbps, which can be supplied by 6.25 transponders. The cost of these transponders is shared by the 2.5 million classrooms of the system.

Evaluation of the Domsat proposals of the March 22, 1972 Federal Register suggests an average investment per transponder of \$2 million, with a variation from \$0.9 million to \$3.4 million. The same document indicates that 56 percent of transponders are prime. Hence, the nominal active transponder represents an investment of \$2.88 million.

A TYPICAL NATIONAL DATA TRANSFER NETWORK FOR COMPUTER-BASED EDUCATION

TYPICAL SYSTEM COSTS (\$/HOUR) FOR EXPERIMENTAL CAI DELIVERY

| <u>BASIC LEASE COST COMPONENTS</u> | <u>MINIMUM CONFIGURATION</u> | <u>HIGH-SPEED LINE</u> | <u>CONCENTRATOR</u> |
|------------------------------------|------------------------------|------------------------|----------------------|
| REMOTE DATA TERMINAL | 0.114 - 0.455 | | |
| DATA TERMINAL PORT | 0.189 - 0.189 | | |
| PACKET CHARGE | 0.300 - 0.300 | | |
| CONCENTRATOR/USER | 0.032 - 0.032 | | |
| DIAL-UP CHARGE | 0.700 - 0.700 | | |
| | <u>1.335 - 1.676</u> | <u>2.155 - 2.496</u> | <u>5.153 - 5.494</u> |

NOTES

COST BASED ON 22 DAY USAGE/MONTH, 6 HOURS PER DAY, I.E., 132 HOURS/MONTH AND 9 ACTIVE MONTHS PER CALENDAR YEAR.

PACKET CHARGE IS FOR 500 PACKETS PER HOUR, OR 5×10^4 BITS/HOUR.

ADDITIONAL INDIRECT SYSTEMS COSTS ARE INVOLVED WHICH ARE NOT INCLUDED. THESE DEAL WITH CAI PROGRAM CREATION, COSTS FOR CENTRAL COMPUTER UTILIZATION AND COSTS OF CURRICULUM MAINTENANCE. THE LATTER TWO COSTS ARE ESTIMATED TO BE ABOUT \$80,000 PER YEAR, THE TOTAL COSTS BETWEEN \$12 AND \$20 PER STUDENT.

TERRESTRIAL AND SATELLITE COST COMPARISON FOR A NATIONAL CAI SYSTEM

Between 1972 and May 1976, the wholesale manufacturing price index moved from 119.8 to 176.6, a factor of 1.474. Hence, today the investment per active transponder is estimated to be \$4.25 million based upon \$2.88 million in 1972.

Universal terrestrial telecommunications practice indicates that for an economically viable operation, the annual revenue from the investment should be on the order of one third of the investment, whereas the DOMSAT proposers indicated a tendency to a 40 percent annual recovery. A representative nominal transponder revenue is therefore \$1.56 million. Averaged over the range, the required revenue would be \$1.68 million, for a nonpreemptible transponder. Currently INTELSAT requires for this kind of transponder \$2.9808 million per year. In 1972 the INTELSAT proposal required revenue approximately 175 percent above the average DOMSAT proposal. It is interesting to note that if this same factor applies today, the current INTELSAT revenue per transponder per year converts to an average of \$1.70 million per year ($\$2.9808/1.75$).

The cost to the schools for transponders will be assumed to be 6.25×1.68 or \$10.5 million per year. Each school, it is assumed, must invest in a transmit-receive antenna at a cost of \$10,000 and a receiver and transmitter at \$300 each. This investment is amortized over 5 years and allocated over 23 classrooms in each school. The space segment shared cost is \$0.0035 per terminal per hour and the Earth segment cost is \$0.0776 per terminal per hour.

If all the 2.5 million classrooms do not belong to the system, the space segment cost allocation per classroom increases: If today, only 7730 classrooms or approximately 336 schools subscribed, then the system cost is indifferent to the form of delivery.

Five years hence, in 1982, indifference to delivery will occur with 8934 classrooms subscribing or about 385 schools, because data transfer equipment costs are expected to decline.

Based on the cost involved in this analysis, therefore, about 0.31 percent of the nation's schools would be required as a subscribing core of CAI users. The core investment in the earth segment is about \$4.1 million, and if remote data terminals were invested in, the average investment would be \$22.3 million.

The potential cost savings then grow as more schools and their classrooms join the core of the system. If all classrooms joined the system, the total investment in the earth segment would be \$1.17 billion and the average investment in terminals \$6.25 billion.

TERRESTRIAL AND SATELLITE COST COMPARISON FOR NATIONAL CAI SYSTEM

| SYSTEM | TODAY | * 5 YEARS HENCE |
|--|----------------|-----------------|
| TERRESTRIAL \$/TERMINAL/HR | 1.335 - 1.676 | 1.101 - 1.203 |
| <u>SATELLITE</u> | | |
| \$/TERMINAL/HOUR | 0.195 - 0.536 | 0.115 - 0.218 |
| COMPETITIVE FACTOR | 6.85 - 3.13 | 9.57 - 5.52 |
| <u>AGGREGATED POTENTIAL ANNUAL SAVINGS</u> | \$3.39 BILLION | \$2.93 BILLION |
| PER TERMINAL/HR. | \$1.14 | \$0.99 |
| PER CLASSROOM/ YEAR | \$1354 | \$1176 |
| PER SCHOOL/ YEAR | \$31,149 | \$27,051 |
| PER PUPIL/ YEAR | \$54.16 | \$47.04 |

* 5 YEARS HENCE, GENERAL DATA TRANSFER USAGE WILL REDUCE DATA TRANSFER EQUIPMENT COSTS TO 30 PERCENT OF TODAY'S. IT IS NOT CLEAR THAT TERRESTRIAL CONNECTIVITY COSTS WILL DECLINE IN THAT TIME.

CONCEPTS FOR SOCIAL UTILITY FROM DATA TRANSFER APPLICATIONS TO ANOMALOUS SCHOOL POPULATION EDUCATION

Two concepts of application of data transfer are discussed which could contribute to alleviation of two current national problems.

One concept deals with the education of anomalous groups in school populations, the dropouts, the gifted and talented, and the homebound disabled or handicapped.

The federal government has spent, and is still spending, considerable sums to develop programs appropriate to the needs of these populations. It is suggested that some component of their needs could be provided through data transfer which makes available interactive material and resources individually to the students involved through a process of communication, from either one centralized facility or some set of regional facilities.

Every school system has to deal with anomalous groups and some part of teaching staff must be specially trained to provide appropriate education. Data transfer could also contribute to staff training programs.

Dropout prevention has further national advantages; it could reduce the load of the Adult Education Act programs and potentially reduce either prison education needs or prison populations or both.

H. M. Levine of Stanford University in a study entitled, "The Effects of Dropping Out" equated the loss from dropouts in revenue alone at \$237 billion over a 25-year time span. ESEA, Title VIII, Section 807 responded to this with the Dropout Prevention Project. This project is reported in DHEW Publication No. (OE) 73-12300, 1973, "Positive Approaches to Dropout Prevention." Funding was spent for innovative experiments in 19 different jurisdictions throughout the nation and during 5 years produced in these localities a 52 percent reduction in dropouts. Currently Title VIII is terminated with responsibility for the program transferred to Title IV, Part C, state and local authorities.

The Title VIII experiment resulted in per pupil costs which varied from \$87 to \$1386, depending on the prevention approach taken. One project, More Alternatives for Students (MAS), conducted by the Hartford Board of Education, Connecticut, involved computer use, primarily for attendance and disciplinary statistics and reporting on 4900 students.

CONCEPTS FOR SOCIAL UTILITY FROM DATA TRANSFER
ANOMALOUS SCHOOL POPULATION EDUCATION APPLICATION

| POPULATION | POPULATION SIZE | NATIONAL EXPENDITURES | |
|------------------------|------------------------------|-----------------------|---------------------------------------|
| HIGH SCHOOL DROPOUTS | 0.8 - 1 MILLION | ESEA VIII, 807 | 1968 \$ 43 MILLION |
| ADULT EDUCATION | 73 MILLION ADULTS | | 1976 \$ 2 MILLION |
| PRISONS | 0.4 MILLION ADULTS | AEA USC 1201 | 1973 \$70.5 MILLION |
| GIFTED & TALENTED | 2-5% OF SCHOOL POPULATION | ESEA III AND V | 1975 \$2.56 MILLION |
| HOUSEBOUND HANDICAPPED | ? | | 1976 \$300 MILLION ALL HANDICAPPED |

REDUCTION OF HIGH SCHOOL DROPOUTS

Causes for dropping out of school are complex and ill defined. Suffice it to say that a dropout's socio-economic, ethnic and psychological context is inappropriate to the context of the school and its process of education. Symptomatically potential dropouts can be identified. Programs of prevention are a series of interventions by specially trained staffs with students to reduce or eliminate symptoms. Some dropout characteristics and program requirements seem consistent with data transfer capabilities, perhaps in concert with TV programming.

Computer-based education, through its programs in drill and practice, has successfully advanced student grades and improved comprehension of the English language. Other suggested uses are perhaps advanced most by combining with TV for career opportunities, social concepts and self-image development.

Data transfer directed to dropout prevention is likely to be an integral part of all programs, rather than a program itself. It is not known, therefore, to what degree data transfer, if completely successful where indicated, would reduce the dropout population.

H. M. Levine's estimate amounts to a social loss on the average of \$9.5 billion annually. Judgmentally it is estimated that data transfer could be instrumental in from 0.1 percent to 10 percent reduction in dropouts, thus producing a social benefit ranging from \$9.5 million to \$950 million annually.

Based on current per pupil costs for dropout prevention, assuming an annual dropout population of one million, the proposed reduction would cost from \$87,000 to \$138.6 million and the use of data transfer dropout prevention may produce a cost reduction on this amount, as well. These derived costs are based on the per pupil cost ranges of the Title VIII experiments.

REDUCTION OF HIGH SCHOOL DROPOUTS

APPROACH

A CENTRALIZED COMPUTER-BASED EDUCATIONAL (CBE) ACTIVITY COULD RESPOND TO FOLLOWING UNIVERSAL ELEMENTS OF DROPOUT PREVENTION

- READING TWO GRADES BELOW NORM
- MATHEMATICS TWO GRADES BELOW NORM
- CURRENT FAILURE IN TWO OR MORE COURSES
- DIFFICULTIES WITH ENGLISH BECAUSE OF ETHNIC BACKGROUND
- FAILURE TO APPRECIATE CAREER OPPORTUNITIES
- INADEQUATE SOCIAL CONCEPTS AND SELF-IMAGE
- IN-SERVICE TRAINING FOR TEACHING STAFF
- SCORING OF STUDENT PROGRAMS
- STUDENT MONITORING: ATTENDANCE, TARDINESS, SUSPENSION, ETC.
- MULTI-PHASIC HEALTH SCREENING.

IT MAY BE POSSIBLE TO INTRODUCE CBE FOR THIS SPECIAL PURPOSE

PROBLEM

- EDUCATORS HAVE NOT USED CBE FOR DROPOUTS
- IT IS NOT KNOWN HOW SUCCESS IN ABOVE COULD REDUCE DROPOUT RATE
- CMI HAS BEEN USED BY USN SATELLITE PROGRAM AND HAS REDUCED THEIR ATTRITION RATE. CMI IS COMPUTER-MANAGED INSTRUCTION.

SOCIAL UTILITY

EACH 1% OF ANNUAL DROPOUT REDUCTION EQUIVALENT TO \$95 MILLION

SOCIAL BENEFITS AND COST SAVINGS ESTIMATES FOR THE EDUCATION OF ANOMALOUS GROUPS

Adult Education has as its targets a population of 57 million adults who have not completed secondary education and 15 million adults who have not completed primary education. In the period 1968-72 the average annual cost per student in the first group was \$90.00 and the second group \$470.00. The New Jersey Education organization dealing with High School Completions estimates that it requires 200 hours of instruction to recover 3 or 4 grades. Since adult education programs are evening courses it is assumed that this is equivalent to about 2 years of instruction at a total cost of \$180. Reducing the dropout population would reduce the potential costs of the adult education program by from \$0.09 million to \$9 million annually.

The national prison population is about 400,000 inmates. The Federal Bureau of Prisons estimates that 90 percent of this population are high school dropouts. The prison population in 1974 cost the nation \$3.24 billion for corrections or about \$8,100 per prisoner per year. The annual incremental population is about 4,000, 3,600 of whom are assumed to be high school dropouts. The dropout program tentatively could conceivably reduce this number by a factor of 3.6 to 360 at an annual savings from \$29,160 to \$2.92 million.

Some 1 to 2.5 million students in all grades of school are considered to be gifted and talented. The 1975 federal funding of \$2.56 million has established 55 projects for defining programs, methods and staff training appropriate to their needs. Projects range in duration from 12 to 36 months, and no results are yet available. Some percentage of this group drops out of school--the bright dropouts.

Nationally there are about 7 million handicapped children, 40 percent of whom are stated to be inadequately educated. Some fraction of the total is confined to their homes and experiments are underway (for example, in New York State) to educate these children using communications, data transfer and television. In the future, all teachers are expected to be versed in special education. During the next 10 years about 1.3 million educators and administrators must receive in-service training in special education and it has been suggested that this could be accomplished by a computer-based education utility (CBEU) (Keith A. Hall and Harold E. Mitzel, The Pennsylvania State University). It is not clear that benefits will evolve from in-service training.

Education of anomalous groups requires for its basic elements specialized education programs and specialized training programs and facilities. Its replicative needs throughout the national educational system suggest centralization of appropriate materials based on studies made by educators of the solutions to the specialized problems. Since material must be made available to all communities, a satellite connectivity is suggested for distribution of computer-based education content of the programs. At present, it must be emphasized that there has been little use of CBE in these programs, yet indications are there that CBE could be appropriate.

SOCIAL BENEFITS AND COST SAVINGS ESTIMATES
FOR THE EDUCATION OF ANOMALOUS GROUPS
(\$ MILLION PER YEAR)

| | SOCIAL BENEFITS | COST SAVINGS |
|-----------------------|-----------------|--------------|
| HIGH SCHOOL DROPOUTS | 9.5 - 950 | |
| ADULT EDUCATION | | 0.09 - 9 |
| PRISON POPULATIONS | | 0.03 - 3 |
| GIFTED & TALENTED | NOT ESTIMATED | |
| HOMEBOUND HANDICAPPED | NOT ESTIMATED | |
| <hr/> | | |
| TOTALS | 9.5 - 950 | 0.12 - 12 |

REDUCTION OF MEDICAL HISTORY RECONSTRUCTION TIME SOCIAL UTILITY

Social utility can be provided by another concept dealing with a basic national problem. This concerns patient medical records and histories.

Medical practice clearly assigns a fundamental role to patient personal, medical and clinical records collected longitudinally or over time. Collectively these records should contain the essential known medical particularities of every patient and be maintained as a reference basis from which future diagnostic evaluations and prescriptions can be guided.

The records, in general, emerge from interrogatory dialogues between physician and patient to which is added essential medical and clinical inserts as a consequence of health episodes. Record dialogue evidently serves other important evaluative functions in medical practice.

Each initial encounter between a patient and a completely new physician requires a reconstruction of the historical records, the fidelity of which must be determined by the patient's memory.

It is suggested that it would be more productive, clinically and medically, if patients' histories were established from birth as an individual medical computerized data base, maintained until death, most likely as a limited access file or as a general access file with anonymous identification

Such a file, accessible and transferable via satellite communications, would be accurately maintained in a medically pertinent manner and be available anywhere globally and in emergencies. The anonymous access could be employed to generate medical, clinical and disease statistics which could be useful in medical training; and the computer could be used to generate medical and clinical profiles of patients that could be universally understood. While such files and their maintenance constitute a substantial data-handling problem together, demanding research for effective combinatorial file manipulation, it is contended that such files could be an indispensable adjunct to future health service structures as they are reorganized for maximum productivity.

REDUCTION OF MEDICAL HISTORY RECONSTRUCTION TIME SOCIAL UTILITY

BASIS

- PATIENT HISTORY IS FUNDAMENTAL TO MEDICAL CARE
- EACH PATIENT/NEW PHYSICIAN ENCOUNTER IMPLIES HISTORY RECONSTRUCTION
- RECONSTRUCTION FIDELITY DEPENDS ON PATIENT MEMORY
- PATIENT COSTS, PHYSICIAN TIME WASTED ON RECONSTRUCTION

SOLUTION

- INDIVIDUAL MEDICAL HISTORY COMPUTERIZED DATA BASE, BIRTH TO DEATH

ADVANTAGES

- MORE CLINICALLY FACTUAL
- MORE MEDICALLY ACCURATE
- AVAILABLE IN EMERGENCIES
- AVAILABLE GLOBALLY
- PROCESSABLE FOR PHYSICIAN USEFUL PROFILES
- BETTER CLINICAL AND MEDICAL STATISTICS
- USEFUL FOR MEDICAL TRAINING
- SIGNIFICANT TO HEALTH SERVICE REORGANIZATION FOR PRODUCTIVITY

PROBLEM

- RECORD PRIVACY MAINTENANCE BUT PRIVILEGED ACCESS AND CONTROL SEEMS POSSIBLE

REDUCTION OF MEDICAL HISTORY RECONSTRUCTION TIME-COST SAVINGS ESTIMATES

In this study such files are viewed as a mechanism for eliminating reconstruction of medical histories and the patient costs that are associated.

During 1974 there were 1,025 million visits made to physicians by the U.S. population.¹

During 1974 the U.S. population was about 211 million. As an average, therefore, there were about 5 visits per person to a physician per annum.

It is assumed that new physician patient encounters result from population mobility. During 1975, 41.3 percent of the population changed houses, but 24.2 percent remained in the same county. It is assumed therefore that 17.1 percent were involved in medical history reconstruction.

This mobile group accounts for 175 million physician visits. Of these, on the average it is assumed 35 million visits were initial encounters between physician and patient.

Net average incomes for GPs (1976) are annually \$44,500 and for internists \$53,900, an average net income being \$49,350. These physicians work an average of 57.5 hours per week or an assumed 2,875 hours per year of active medical work (HEW research and statistics note No. 13, July 21, 1977). Thus, the average net income of those physicians most likely to engage in record reconstruction is \$17.17 per hour or \$0.0048 per second.

Thus, conservatively for the population involved, per annum, there is a cost of \$0.16 million per second of record reconstruction time saved.

Judgmentally it is estimated that each record reconstruction may require an average of 5 minutes, with a likely range from 1 minute to 15 minutes.

Thus a nominal cost saving is estimated to be \$48 million per year with a range from \$10 million to \$144 million per year.

The nominal cost saving of \$48 million per year is equivalent to about 0.29 percent of national private expenditures on physicians.

¹ Statistical Abstract of the United States, 1976

REDUCTION OF MEDICAL HISTORY RECONSTRUCTION
TIME COST-SAVINGS ESTIMATES

| | |
|-----------------------|--|
| BASIC SAVING: | \$0.16 MILLION PER YEAR/SECOND OF RECORD RECONSTRUCTION TIME SAVED |
| NOMINAL COST SAVINGS: | \$48 MILLION PER YEAR (5 MINUTES OF RECORD RECONSTRUCTION TIME SAVED) |
| COST SAVINGS RANGE: | \$10 MILLION TO \$144 MILLION PER YEAR (1 MINUTE TO 15 MINUTES) |

NOMINAL COST SAVINGS IS ABOUT 0.29 PERCENT OF NATIONAL PRIVATE EXPENDITURES
ON PHYSICIANS.

PERSONAL MEDICAL AND CLINICAL HISTORY ACTIVITY BY MEDICAL PROFESSION SOCIAL UTILITY

To support the concept of social utility generation from records which are computer-structured and managed, a single research project is isolated from many undertaken by the medical profession since 1960.

This program is supported by the National Center for Health Services Research (HEW). The program is called PROMIS, Problem Oriented Medical Information System reported in DHEW publication (HRA) 77-3177, April 1977 titled "Automation of the Problem Oriented Medical Record."

The development has been granted \$4.3 million and is directed by Dr. Lawrence L. Weed at the University of Vermont, Burlington, Vermont.

PROMIS is concerned with in-hospital patient data bases and records. It is a procedure to coordinate patient care by its many providers, which eliminates reliance on memory, records the logic of treatment and provides feedback loops. It aims to eliminate the extraneous, irrelevant and inaccurate in in-patient care. The system in its preliminary stages was operated in the gynecology ward of a large teaching hospital. More recently it has been in operation on the general medical ward at the University of Vermont.

The research was constrained by the absence of a reliable computer and by the relative slowness of system response.

According to Dr. Herbert Sherman of the Harvard School of Public Health, a coordinator of PROMIS, the system does not yet work for ambulatory patients because of computer limitations.

The system is currently being updated and improved with the intent of adding a medical literature data base.

PERSONAL MEDICAL AND CLINICAL HISTORY ACTIVITY BY MEDICAL PROFESSION
SOCIAL UTILITY

SINCE 1960

- THE COMPUTER AS A CONSULTANT
- PATIENT-COMPUTER DIALOGUE
- COMPUTER REMINDERS--THE QUALITY OF CARE, THE NONPERFECTABILITY OF MAN
- AUTOMATION OF THE PROBLEM-ORIENTED MEDICAL RECORD (PROMIS)
- ATS-6 AND THE PAPAGO INDIANS AND THE ALASKAN NATIVES

CONCLUSIONS

This study has resulted in the estimation of some cost savings and social benefits that could arise from the employment of data transfer in public service activities. It is a technical fact that data transfer can be achieved by use of satellite connectivities. Public service experiments in data transfer using satellites have so far been inadequate for substantive evaluation and little guidance results to indicate public service applications that will produce economic benefit which can be substantiated through acceptance and approval by those responsible for public services implementation and results.

As a consequence, the content of this study and its results in particular are founded more on a theoretical basis than an experimental one. Many well-funded experiments are, however, undergoing development in data transfer and these experiments, where known and applicable, are used to support the theoretical developments.

The study has broadly investigated the economic benefits of public service data transfer potential. Estimation of the total national data transfer in public service projected for 1982 allows a cost comparison between communication connectivity supplied terrestrially and by satellite. Compared to today's terrestrial connectivity prices and the reasonable assumption that satellite connectivity will be less, each 1 percent reduction provides a cost saving of \$2.08 million per year with a range due to uncertainty in data rate from \$0.35 million to \$3.54 million per year. Total cost savings are then postulated on a satellite connectivity cost reduction capability of 50 percent so that the total annual cost savings envisaged is nominally \$104 million but with a range from \$18 million to \$190 million. This cost saving is a lump cost savings which assumes that in 1982 public service data transfer will demand its projected share of 418 Mbps. It is far from clear that this will actually be the implementation mechanism. It is more likely that this public service projected share will be implemented over a period of time even with a satellite available. This time dependence is controlled by those responsible for defining the public service utility of data transfer and as this is an area of considerable controversy it cannot be reasonably predicted at the present time. Consequently, these cost savings cannot be translated into economic benefits. Using very elementary control for a public service packet switched network (0.16 capacity is equal to throughput) data transfer in public service would require about 76 transponders (35 Mbps each). With much more sophisticated control only about 12 such transponders would be required.

An example of computer-based education, expanded from a current small-scale terrestrial experiment to a national system encompassing all schools and colleges, indicates both connectivity cost savings and constraints which are important to defining these cost savings. If such a national system should exist in 1982 (and there is no indication that it will) then cost savings could be as large as \$2.93 billion annually, compared to

the system prices prevailing in the current experiment. (It might be argued that these savings estimates are excessive because of tariff assumptions compared to those of the first reported investigation. In this experiment a channel cost was \$0.30 per hour to carry about 14 bps on the average, while in the first reported investigation a channel cost was \$3.50 per hour to carry a nominal 9600 bps with a variation from 1600 to 16000 bps approximately. If channel bandwidth were a part of the tariff then the national CBE network tariff is quite expensive compared to the general network tariff.) The implementation of this national network completely would require a total educational investment of about \$7.42 billion (\$1.17 billion in earth segments and \$6.25 billion in data terminals). This is about 6.8 percent of the national education budget of \$109 billion in 1974-75 and the diversion to CBE delivered by satellite would require a commitment by the education community to CBE. Cost savings could also be influenced by the structure of delivery. This analysis assumes a single centralized distribution. It is also clear that computer-based education must develop a core aggregation of schools desirous of using CBE for satellite delivery to provide cost savings. In this study it is estimated that the core aggregation required is that of 8934 classrooms or all the classrooms of 385 schools. This is about 0.31 percent of all the nation's schools. Each such school would have to invest on the average \$10,600 in its ground segment and \$57,500 in its data terminals. Thus the core aggregation must invest about \$26.4 million. The annual core aggregation cost savings would be \$10.5 million.

If CBE is introduced at a slower rate than through an initial core aggregation, then each school will select the terrestrially delivered system which costs less than the satellite delivered system and will then invest in the terrestrial equipment necessary to its connectivity choice.

With a minimum core aggregation, cost savings develop in time with the satellite system as additional schools decide to join the CBE network. How the progression of participation in the network would proceed in time is impossible to predict since it is at the discretion of state and local school districts or authorities. Hence the estimated cost savings cannot once again be translated into economic benefits. The CBE system assumed requires the data transfer throughput of 35 Mbps.

Two examples are then developed which are concepts of the social utility of data transfer in public service. These concepts are pertinent to current national problems and interests.

The first application concept relates to high school dropout prevention and the general problem of the education of anomalous groups. Anomalous groups describe those groups to be educated which demand anomalous financing from the education system and include dropouts, the gifted and talented, and the handicapped confined to home. Each of these classes requires specially developed programs of education and specially trained staff. Anomalous groups in education are a concern of all the nation's schools, and the federal government has spent considerable sums to develop successful exemplary programs.

The concept assumes that each class of interest will require well-documented adaptable exemplary programs for students and staff and that these programs will include some employing data transfer. Conceivably then an education center could distribute programs as requested by each school via satellite so as not to exclude any schools from having access.

Direct potential social benefits to dropout prevention are estimated to range from \$9.5 million to \$950 million annually, the range resulting from lack of knowledge of the impact of data transfer on the problem, as one of many tools. As a consequence of reducing the number of dropouts the adult education system can save from \$0.09 million to \$9 million per year and it is estimated that the prison population will be reduced, producing an annual savings ranging from \$0.03 million to \$3 million. All of these savings are social benefits, potentially, yet clearly their realization is dependent on the success of dropout prevention which is not wholly dependent on data transfer for its success.

Exemplary program development for the gifted and talented is just beginning and no potential social benefits have been estimated. Experiments are being initiated to provide education to the handicapped confined to home and no potential social benefits have been estimated. This concept for education is based on the stated problems of potential high school dropouts which seem to be universal, as reported by educator's studies.

A further concept example for the application of data transfer is based on the potential for reducing the repetitive reconstruction of medical histories and records for patients when they encounter a new physician. The objective of creating personal medical data bases and maintaining them throughout a patient's life, with limited access and anonymity of data, is suggested. Such a concept evidently requires a dedication of funding for such an aggregated population data base. Yet with its availability, other medical uses can be visualized. The concept is supported as a proposition through a current medical system development which is funded and has been successful in in-hospital use.

Cost savings are based on population mobility and are estimated to be \$0.16 million per second of record reconstruction time saved. Judgmentally a nominal reconstruction time saving is assessed at 5 minutes and a consequent nominal cost saving at \$48 million annually. Clearly the time history of development of such a system is difficult to estimate and economic benefits are not derived. The range of cost savings is estimated to be from \$10 million to \$144 million annually due to difficulty in estimating record reconstruction time savings.

The various cost savings estimated and the estimated social benefits are tabulated.

With the extensive and growing activity motivated by the data transfer applications of business, it is reasonable to ask if a dedicated public service satellite is necessary for the data transfer requirements of public service. The answer to this question must arise from the structural requirements of a public service network and a business service network and the different forms of constraint on the system usages that are significant.

CONCLUSIONS

PUBLIC SERVICE DATA TRANSFER ESTIMATES OF ANNUAL COST SAVINGS AND SOCIAL BENEFITS, CIRCA 1982 (\$ MILLION)

| | COST SAVINGS | | SOCIAL BENEFITS |
|---|----------------|--------------|-----------------|
| | <u>NOMINAL</u> | <u>RANGE</u> | <u>RANGE</u> |
| NATIONAL NETWORK CONNECTIVITY | 104 | 18-190 | |
| NATIONAL COMPUTER BASED EDUCATION | 2930 | 11-2930 | |
| HIGH SCHOOL DROPOUT PREVENTION | | | 9.5 - 950 |
| ADULT EDUCATION | | | 0.09 - 9.0 |
| PRISON POPULATION | | | 0.03 - 3.0 |
| MEDICAL HISTORY RECONSTRUCTION REDUCTION | 48 | 10-144 | |
| TOTALS | 3082 | 39-3264 | 9.62 - 962 |

2.4 POTENTIAL BENEFITS OF IMPROVED COMMUNICATIONS IN A SEVERE STORM WARNING SYSTEM

SYSTEMS MODEL OF A WARNING SYSTEM

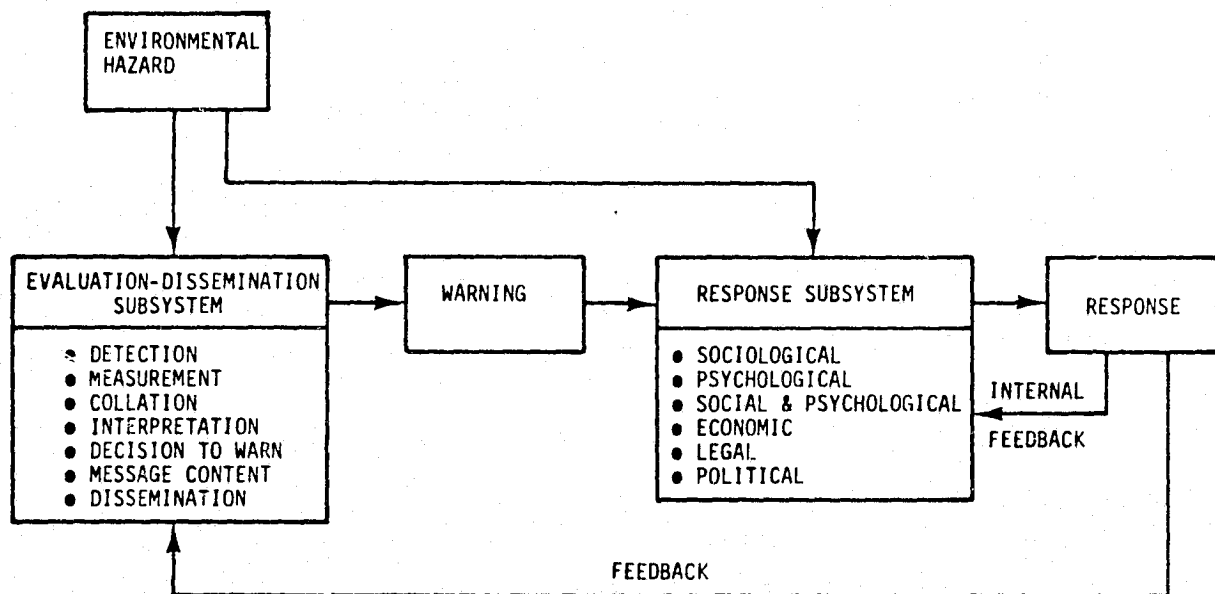
Timely warnings in advance of the onset of severe storms have a large potential benefit in terms of both saving human casualties and reducing property damage. This section presents one approach at quantifying the potential benefits that would accrue from an improved communication system as a portion of the benefits of a severe storm warning system. Within the current structural framework, the communications system is one of three major activities, all of which contribute to the total benefits of a severe storm warning system. The three components are:

- Forecast
- Communications and dissemination
- Response.

As will be discussed later, all three components are subject to improvements and are very much interrelated. For example, a perfect forecast is useless if it cannot be effectively disseminated, and timely dissemination of bad forecasts might yield a net disbenefit. Another crucial question is, what motivates response in people once they have received a severe storm forecast? This section will concentrate upon the communications and dissemination activities and will briefly address the questions of forecast and response.

A second point to be recognized is that it might not be possible to reduce property damage proportionately as much as human casualties. For example, if a person knew with certainty and with sufficient lead time that a large tornado was going to hit his home, there would be little that he could do to save the structure of his home. Another less obvious example is that if a hurricane occurred after a drought, the precipitation from the hurricane would actually provide a benefit in some areas. For the above reasons, this section will concentrate upon the benefits of improved communications and dissemination on preventing human casualties.

SYSTEMS MODEL OF A WARNING SYSTEM



SOURCE: DENNIS S. MILETI, NATURAL HAZARD WARNING SYSTEMS IN THE UNITED STATES: A RESEARCH ASSESSMENT, NSF-RA-E-75-013

MAJOR SOURCES OF DATA

Many previous studies have addressed the question of the impact of severe storms and natural hazards in the United States. A few of these major studies are listed on the facing page. A problem with the previous studies is that the communications system aspects are not sufficiently distinguished from the total warning system aspects to allow for a direct evaluation of the benefits which might accrue due to improvements in communication. The previous studies do, nonetheless, define the current system, the volume of data, and certain specific problems which have accrued.

Historical weather data on severe storms is abundant and is very comprehensive. A monthly publication entitled "Storm Data" put out by the Environmental Data Service of NOAA lists every reported severe storm in the United States. Details of each storm contain at least the type of storm, date, time, length and width, number of deaths and injuries, property damage, and crop damage, as well as a narrative of the specifics of the storm. From this data, a very detailed analysis could be conducted to identify the specific areas in which improved communications could have been beneficial.

A second publication not listed, which lends insights into the human response aspects of severe storms, is one by Mileti, Drabek, and Haas entitled "Human Systems in Extreme Environments: A Sociological Perspective."

MAJOR SOURCES OF DATA

NATIONAL RESEARCH COUNCIL, "SEVERE STORMS: PREDICTION, DETECTION AND WARNING," 1977

MILETI, "NATURAL HAZARD WARNING SYSTEMS IN THE UNITED STATES," NSF-RA-E-75-013

WHITE AND HAAS, "ASSESSMENT OF RESEARCH ON NATURAL HAZARDS," NSF-RA-E-75-001

"OPERATIONS OF THE NATIONAL WEATHER SERVICE," JANUARY 1977

NATURAL DISASTER SURVEY REPORT 74-1, "THE WIDESPREAD TORNADO OUTBREAK OF APRIL 3-4, 1974," DECEMBER 1974

MAUNDER, THE VALUE OF WEATHER, 1970

WHITE, "FLOOD HAZARD IN THE UNITED STATES," NSF-RA-E-75-013

COMPUTER SCIENCE CORPORATION, "DISASTER WARNING SYSTEM: SATELLITE FEASIBILITY AND COMPARISON WITH TERRESTRIAL SYSTEMS," NASA CR-1346122, R-3015-3-1

NATIONAL WEATHER SERVICE FORECAST ORGANIZATION

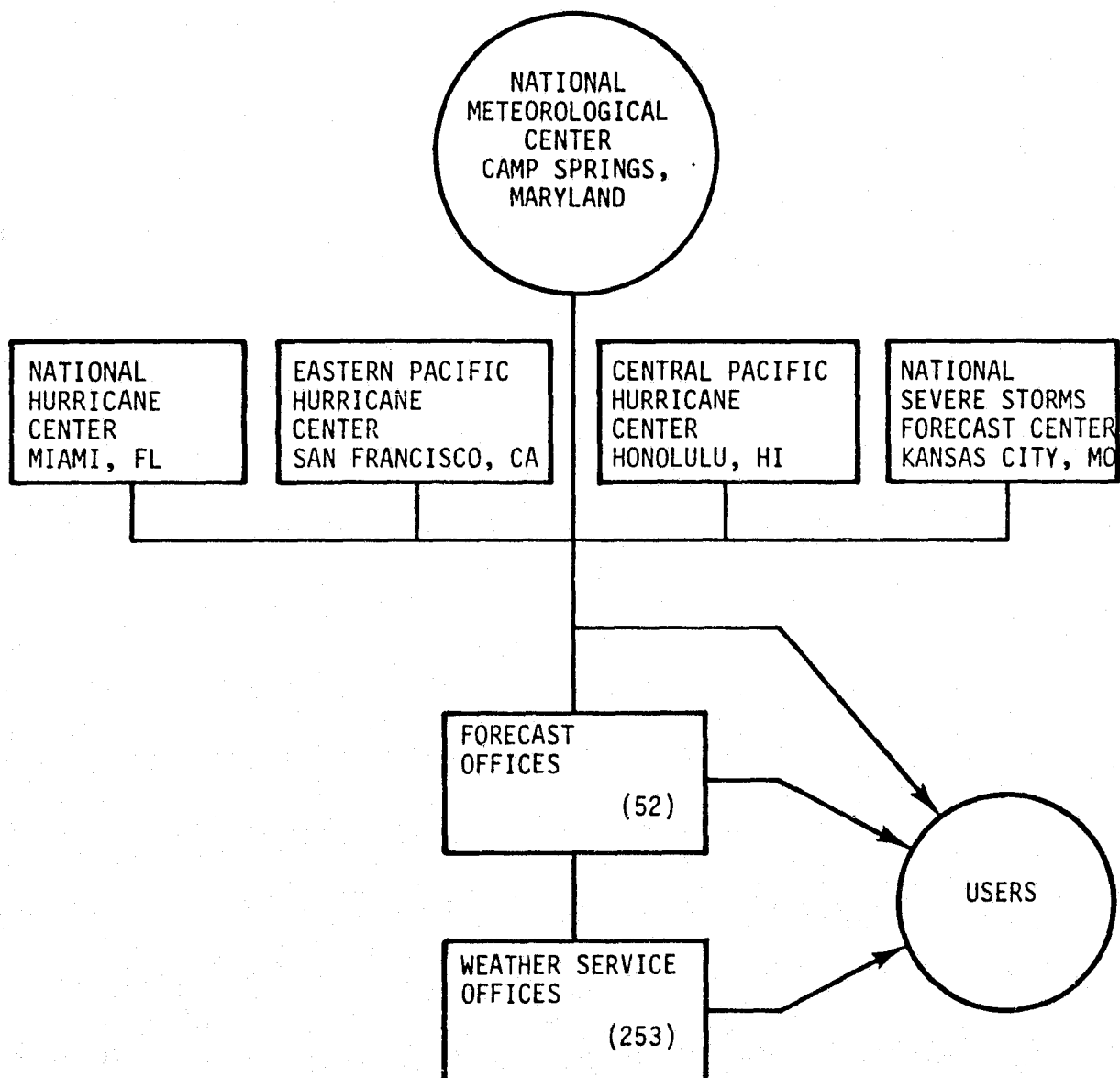
The National Weather Service (NWS) annually publishes a description of the operations of their operations including the number of facilities, number of employees, number of weather observations taken, and the number of forecasts and warnings issued. The organizational chart of NWS is presented on the facing page.

The National Meteorological Center is the overall center for all NWS operations with specialization found in the National Hurricane Center, the Eastern and Central Pacific Hurricane Centers and the National Severe Storms Forecast Center. These specialized centers provide a single source for information about hurricanes or severe storms.

The Forecast Offices (WSFOs) are responsible for warnings and forecasts for states or large portions of the states and assigned zones. A 48-hour forecast is issued twice daily, while a 5-day forecast is issued daily. In addition, areawide or statewide warnings are issued to the public in critical weather situations.

The Weather Service Offices (WSOs) are responsible for adapting the zone forecast to the specific locality and insuring that the warnings and forecasts are made available at the county level.

NATIONAL WEATHER SERVICE FORECAST ORGANIZATION



SOURCE: OPERATIONS OF THE NATIONAL WEATHER SERVICE, JANUARY 1977

NATIONAL METEOROLOGICAL CENTER
(CAMP SPRINGS, MD)

The National Meteorological Center in Camp Springs, Maryland is organized into three divisions and one group with the following functions:

The Forecast Division applies a combination of numerical and manual techniques to produce analyses and prognoses up to five days into the future, emphasizing the period of 2 to 72 hours. It also serves as a High Altitude Forecast Office for basic documentation support to most of the commercial aviation flights serviced by the United States.

The automation division operates NMC's computers and their communications to NWS Communication Division, investigates programs, and tests various techniques for automating NMC operations.

The Development Division conducts and adapts R&D results in numerical weather prediction to the NMC products. It also conducts stratospheric research and investigates the problem of four-dimensional data assimilation.

The Long-Range Prediction Group prepares outlooks for one-month periods and experiments with seasonal outlooks. It also develops techniques for improving these forecasts, including the extension of the period for which they are prepared.

NATIONAL METEOROLOGICAL CENTER
(CAMP SPRINGS, MD)

- FORECAST DIVISION
- AUTOMATION DIVISION
- DEVELOPMENT DIVISION
- LONG-RANGE PREDICTION GROUP

SOURCE: OPERATIONS OF THE NATIONAL WEATHER SERVICE, JANUARY 1977

DAILY THROUGHPUT OF NMC

The centralized preparation of data, analyses, and forecasts at NMC is designed to eliminate most requirements for handcharting and independent meteorological analysis in the field Forecast Offices. NMC, through the use of a large computer facility and together with numerical forecast methods, provides the NWS, other government agencies, and private industry with daily guidance forecasts up to five days in advance.

In the course of these operations, NMC is very heavily involved with communications to and from all parts of the world. The average daily communications are shown on the facing page and clearly show the intensity of the need for communications by NMC. During peak times, these volumes increase greatly and have frequently overloaded the communications system.

C-3

DAILY THROUGHPUT OF NMC

14,000 SYNOPTIC SURFACE AVIATION REPORTS

25,000 HOURLY SURFACE AVIATION REPORTS

2,500 SYNOPTIC SHIP REPORTS

2,500 ATMOSPHERIC SOUNDINGS

3,500 AIRCRAFT REPORTS

ALL AVAILABLE CLOUD AND TEMPERATURE DATA FROM WEATHER SATELLITES

785 FACSIMILIE TRANSMISSION TO FIELD OFFICES

819 TELETYPEWRITER TRANSMISSIONS TO FIELD OFFICES

SOURCES: OPERATIONS OF THE NATIONAL WEATHER SERVICE, JANUARY 1977

OVERVIEW OF WEATHER COMMUNICATIONS

The communications program is vital to the functioning of all service programs and is considered part of the basic weather service. A vast and complex system distributes weather data, including analyses, forecast, and warnings. Most of the system is made up of leased facilities. A significant level of support in this area is provided by the FAA.

The system is designed to:

1. Deliver observed data to users within NWS
2. Transmit processed information from one section of the meteorological system to another
3. Deliver the final product to the user or to mass disseminators.

A typical WSO will have a drop on Service A, Service C, the National Facsimile Network, the RAWARC system, NOAA Weather Wire, and on NAWAS. The number of circuits, printers, facsimile recorders, and other equipment items increases with station activity.

The NOAA VHF-FM weather radio is potentially going to impact the communications of NWS. The National Research Council report states that:

"In an important policy statement, the Office of Telecommunications Policy has designated this system as the only Federally sponsored method for the transmission of natural disaster warning information to receivers optionally available to the general public. A total of 331 transmitters will complete the system and will provide the service to 95 percent of the nation's citizens...These stations, however, have a radio coverage of about 40 miles radius over flat terrain. Hence, only metropolitan areas would be served..."

Since more than 750 stations would be needed to cover 99 percent of the population of the continental United States, and are not envisioned in the proposed system, satellite communications might be applicable to carry the service to the thinly populated areas outside of the metropolitan areas. The benefits of such an application of satellite communications should be addressed at some later date.

OVERVIEW OF WEATHER COMMUNICATIONS

SERVICE A - (170 TELETYPEWRITER CIRCUITS)
SERVICE C - (6 TELETYPEWRITER CIRCUITS)
SERVICE O - (12 TELETYPEWRITER CIRCUITS)
RAWARC - (5 TELETYPEWRITER CIRCUITS)
NATIONAL WARNING SYSTEM (NAWAS)
NOAA WEATHER WIRE, FIRE WEATHER -
 (41 TELETYPEWRITER CIRCUITS)
LOCAL PUBLIC SERVICE LOOPS -
 (19 TELETYPEWRITER CIRCUITS)
INTERNATIONAL - (23 CIRCUITS)

NATIONAL FACSIMILE - (1 CIRCUIT)
NWS FORECAST OFFICE FACSIMILE -
 (3 CIRCUITS)
NATIONAL AND AVIATION METEOROLOGICAL
 FACSIMILE - (1 CIRCUIT)

INTRA-ALASKA FACSIMILE - (1 CIRCUIT)
SUITLAND - HONOLULU MULTIPLEX CIRCUIT
 (1 FACSIMILE, 3 TELETYPEWRITERS)

MULTIACCESS RECORDED TELEPHONE
 ANNOUNCEMENT SYSTEM

MISCELLANEOUS FACSIMILE - (16 CIRCUITS)

MISCELLANEOUS CIRCUITS - (62 CIRCUITS)

NOAA WEATHER RADIO - (84 STATIONS)
VOICE/DATA CIRCUITS - (21 CIRCUITS)
RADAR REMOTE - (28 CIRCUITS)

SOURCE: OPERATIONS OF THE NATIONAL WEATHER SERVICE, JANUARY 1977

NWS DISASTER PREPAREDNESS PROGRAM

Despite advances in technology and skill in forecasting and warning, tornadoes, floods, hurricanes, and other natural disasters continue to take an inordinate number of lives and cause thousands of injuries every year. Costs to federal, state, and local governments are now over \$2 billion per year.

The Disaster Preparedness Program's central thrust is to increase the number of well-prepared communities in the United States. In the local communities which have an effective preparedness plan and educated citizenry, deaths and injuries caused by natural disasters have been low. The plans usually concentrate upon ensuring the rapid dissemination of warnings, and encourage the proper response to the warnings by the local authorities and the public. The aid of the news media is enlisted for an informational-educational campaign to increase public awareness of the threat of natural disasters.

Thus, the area for potential improvements and subsequent benefits is not only the improvement of the actual forecast, but also the improvement of the communication and dissemination of the forecast to a public which has been educated to respond properly.

NWS DISASTER PREPAREDNESS PROGRAM

OBJECTIVE: TO PLAN AND DEVELOP DISASTER PREPAREDNESS PROGRAMS DESIGNED TO SAVE LIVES AND MITIGATE THE SOCIAL AND ECONOMIC IMPACTS OF NATURAL DISASTERS.

IMPROVEMENT AREAS:

FORECAST
COMMUNICATIONS AND DISSEMINATION
RESPONSE

SOURCE: OPERATIONS OF THE NATIONAL WEATHER SERVICE, JANUARY 1977.

WARNING SERVICES IN CURRENT SYSTEM

For each of the specific types of natural disasters which occur with relative frequency in the United States, the NWS has established several programs whose responsibility it is to issue warnings when a severe weather-related condition is likely to occur. The major programs and services are listed on the facing page.

The hurricane warning program is basically a two-level operation. At the top level are the three hurricane centers and their associated Hurricane Warning Offices (HWOs). At the second level are WSFOs and WSOs. The basic products of the hurricane centers and HWOs are tropical storm and hurricane advisory which are distributed every 6 hours to the general public, mass media, and public officials. The WSFOs and WSOs serve as the local contacts.

The Severe Local Storms Warning Program (SELS) is responsible for issuing tornado and severe thunderstorm watches. Local offices issue statements to keep the public informed on weather developments. The major communication techniques used for relaying this information are NOAA Weather Radio, Service A, Service C, RAWARC, and NAWAS.

The Flash Flood Program considers flooding where only a few hours or a few minutes lead time before the flood is available. In these cases, the main objective of the forecast is to save lives, although it may be possible to also save property. Timely warnings of flash floods are dependent upon data automation and a good communications system.

The Coastal Flood Warning Program's objective is to warn the public and concerned special interests along the U.S. coastal areas of unusually high water levels due to tides and waves caused by hurricanes and severe winter storms.

The Winter Weather Warning Service's objective is to warn the public and all other concerned interests of winter storms, blizzard conditions, heavy snow, sleet, freezing rain, freeze, frost, and high winds, in time to take protective measures for saving lives and for minimizing property losses.

The Fruit-Frost Program has two objectives. The primary objective is to issue warnings of low temperatures injurious to winter and spring crops, particularly in citrus and deciduous fruit-growing areas. The secondary objective is to supply general agricultural weather information to the district served.

WARNING SERVICES IN CURRENT SYSTEM

HURRICANE WARNING PROGRAM

TORNADO AND SEVERE LOCAL STORMS WARNING PROGRAM

FLASH FLOOD PROGRAM

COASTAL FLOOD WARNING PROGRAM

WINTER WEATHER WARNING SERVICE

FRUIT-FROST PROGRAM

THE WARNING SYSTEM

Warning systems are more than the ability to properly forecast and/or to effectively disseminate the warning messages to the endangered public. In order to understand a public warning message, how it comes to be, and, most importantly, its consequences for persons in danger, it is necessary to view a total or integrated warning system. Placing the dissemination of hazard warnings in the context of an integrated system has the distinct advantage of bringing to view all of the parts of a warning system, as well as the links between them.

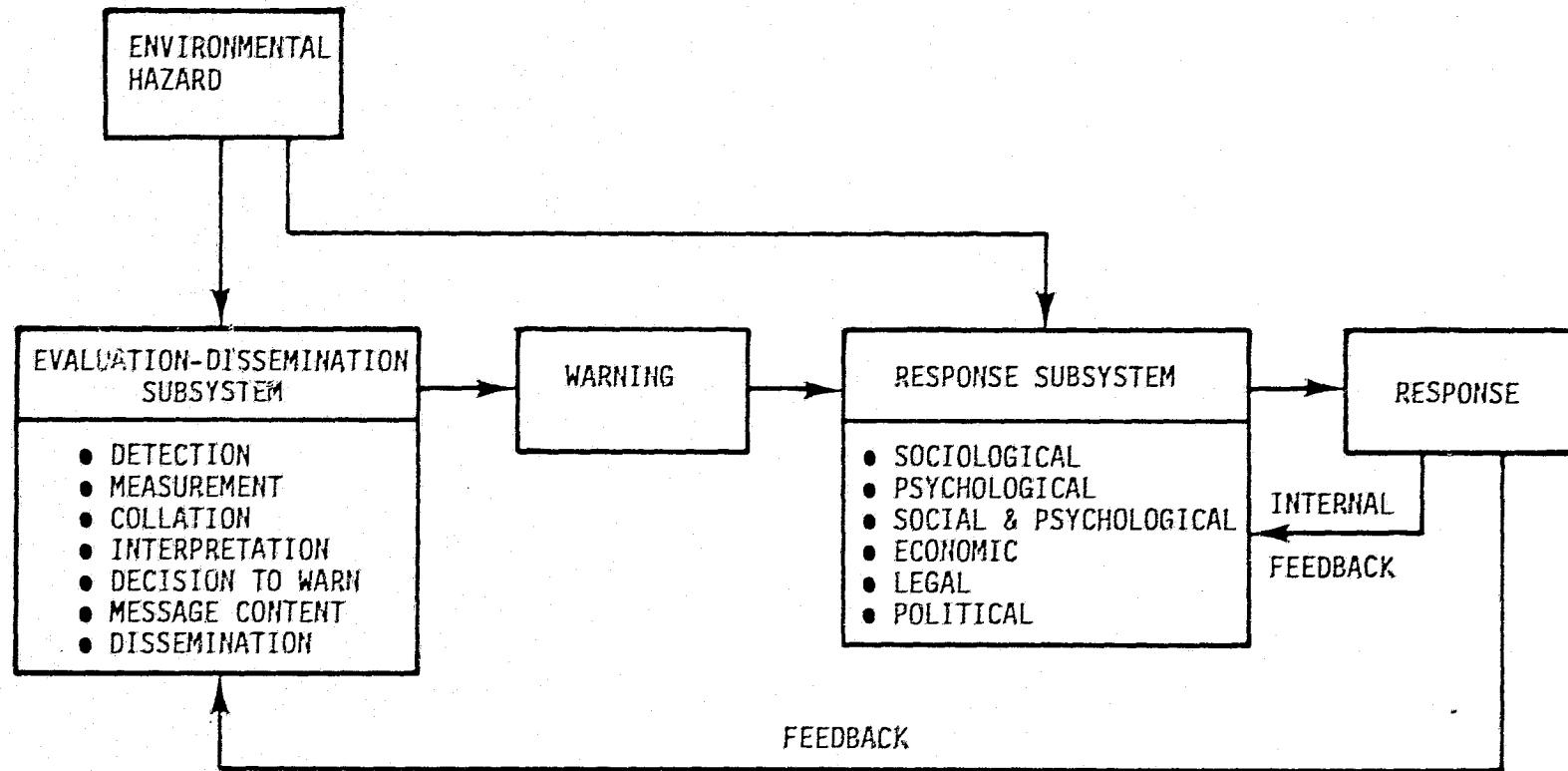
An integrated warning system performs three basic functions:

- Evaluation of the threat
- Dissemination of the warnings
- Response to the warnings.

The dissemination of the warnings is of primary concern to this study. The dissemination of adequate warnings to the endangered public has been shown to be a weak link in warning systems as they are now structured.

THE WARNING SYSTEM

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SOURCE: DENNIS S. MILETI, NATURAL HAZARD WARNING SYSTEMS IN THE UNITED STATES: A RESEARCH ASSESSMENT, NSF-RA-E-75-013

MEAN ANNUAL LOSSES OF SEVERE STORMS AND OTHER NATURAL HAZARDS

The mean annual losses of severe storms and other natural hazards is presented on the facing page. A relatively surprising fact is that lightning has the highest number of deaths. The reason is that lightning injuries and deaths are usually isolated instances and are seldom given the publicity of other severe storms.

The trend in the number of deaths and injuries is consistently downward, implying that people are more aware, or aware sooner of the danger or are taking more precautionary measures to protect themselves. This can be partially attributed to better forecasting techniques, but also to both the better communication and dissemination of the forecasts and the proper response of the public.

Consistent with general economic trends, the amount of per capita property damage has been increasing over time. The problem is that even if a person knew with certainty that a tornado was going to hit his house, there would be little that he could do other than to evacuate. It follows that property damage is less sensitive to improvements in forecast and communication technology.

MEAN ANNUAL LOSSES OF SEVERE STORMS
AND OTHER NATURAL HAZARDS

| <u>STORM TYPE</u> | <u>DEATHS (PER 10M)</u> | <u>INJURIES (PER 10M)</u> | <u>DEATH AND INJURY TREND</u> | <u>PER CAPITA PROPERTY DAMAGE (\$)</u> | <u>PROPERTY DAMAGE TREND</u> |
|-----------------------|-----------------------------|-------------------------------|---------------------------------------|--|--------------------------------------|
| TORNADO | 5.24 | 90.48 | DOWN | 1.2 | UP |
| HURRICANE | 2.52 | 119.52 | DOWN | 2.2 | UP |
| LIGHTNING | 5.43 | 10.95 | DOWN | .5 | UP |
| FLOOD | 3.90 | 50.90 | DOWN | 5.7 | UP |
| URBAN SNOW | 5.19 | 3.19 | SAME | .2 | UP |
| WIND | 4.65 | 29.42 | UP | 1.0 | UP |
| HAIL | - | - | N/A | 2.2 | UP |
| FROST | - | - | N/A | 6.0 | UP |

SOURCE: WHITE AND HAAS, ASSESSMENT OF RESEARCH ON NATURAL HAZARDS,
NSF-RA-E-75-001

EFFECTS OF WARNING SYSTEM

The losses of severe storms and other natural hazards are extremely variable when considered on an annual basis. Tornadoes have killed 9000 people in the last half century. Some years the number of deaths has been under 30, while the 1925 Tri-State Tornado killed nearly 700 people in Missouri, Illinois, and Indiana.

The benefits of improved communications are more likely to be found in the catastrophic occurrences where the peak demand usually overloads the available circuits. For example, in an outbreak of 127 tornadoes on April 3-4, 1974 on one RAWARC circuit 26 of 62 warnings were relayed after their period of validity had expired.

A more conservative approach would be to look at the annual averages which tend to dampen the effects of the catastrophic occurrences. The effects of the warning system are shown on the facing page for both the average and the catastrophic instances.

EFFECTS OF WARNING SYSTEM

| STORM TYPE | REDUCTION OF NET LOSS | | REDUCTION OF HUMAN CASUALTIES | | AVOIDANCE OF SOCIAL DISRUPTION | |
|---------------|-----------------------|------------------------|----------------------------------|--------------|-----------------------------------|--------------|
| | AVERAGE | CATASTROPHIC | AVERAGE | CATASTROPHIC | AVERAGE | CATASTROPHIC |
| TORNADO | LOW | LOW | HIGH | HIGH | MED | MED |
| HURRICANE | LOW | LOW | HIGH | HIGH | MED | MED |
| LIGHTNING | MED | HIGH | LOW | HIGH | LOW | HIGH |
| FLOOD | MED | MED., LOW., OR NEG. | MED | HIGH | MED | MED |
| URBAN SNOW | HIGH | HIGH | MED | HIGH | LOW-MED | HIGH |
| WIND | LOW | LOW | HIGH | HIGH | LOW | LOW |
| HAIL | LOW | LOW | N/A | N/A | LOW | LOW |
| FROST | MED | ? | N/A | N/A | LOW | ? |

SOURCE: WHITE AND HAAS, ASSESSMENT OF RESEARCH ON NATURAL HAZARDS, NSF-RA-E-75-001

ANNUAL BENEFITS OF IMPROVED COMMUNICATIONS IN SEVERE STORM WARNINGS

Using the effects of a warning system in the average case, the mean annual losses, and the current population of the United States, the table on the facing page was constructed. The maximum benefits of the communications portion of the warning system was assumed to be 50, 30, and 10 percent for the high, medium, and low effects, respectively. The minimum benefits are similarly assumed to be 20, 10 and 5 percent. These assumptions yield a range of 78 to 203 lives saved, and 901 to 2947 injuries avoided due to improved communications.

ANNUAL BENEFITS OF IMPROVED COMMUNICATIONS IN SEVERE STORM WARNINGS

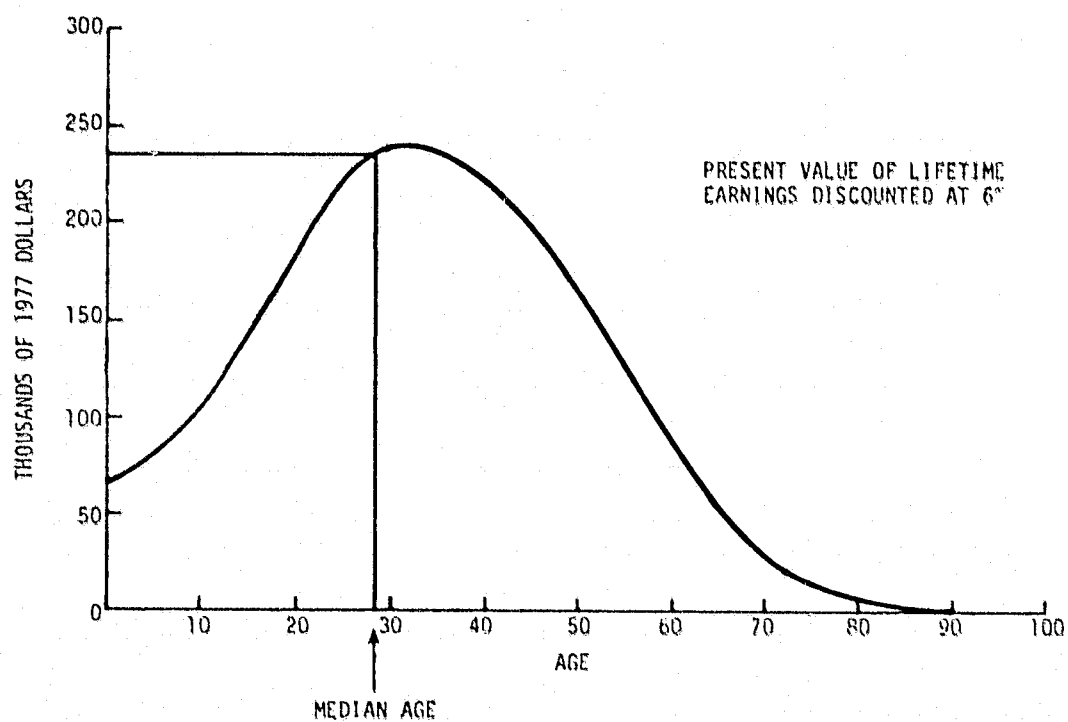
| STORM TYPE | DEATHS | | | INJURIES | | |
|-------------------|-------------------|----------------|----------------|-------------------|----------------|----------------|
| | POTENTIAL SAVINGS | | | POTENTIAL SAVINGS | | |
| <u>STORM TYPE</u> | <u>TOTAL</u> | <u>MAXIMUM</u> | <u>MINIMUM</u> | <u>TOTAL</u> | <u>MAXIMUM</u> | <u>MINIMUM</u> |
| TORNADO | 112 | 56 | 22 | 1,945 | 973 | 384 |
| HURRICANE | 54 | 27 | 11 | 2,570 | 1,285 | 257 |
| LIGHTNING | 117 | 12 | 6 | 235 | 24 | 12 |
| FLOOD | 84 | 25 | 8 | 1,094 | 328 | 109 |
| URBAN SNOW | 112 | 33 | 11 | 69 | 21 | 7 |
| WIND | 100 | 50 | 20 | 633 | 316 | 127 |
| HAIL | - | - | - | - | - | - |
| FROST | - | - | - | - | - | - |
| TOTAL | 579 | 203 | 78 | 6,546 | 2,947 | 901 |

HUMAN CAPITAL APPROACH TO THE VALUE OF A LIFE

Several approaches have been suggested to estimate the value of a human life. One that is frequently used is the human capital approach which employs the present value of lifetime earnings. Much argument exists on the choice of the appropriate discount rate to use and the age to consider. For this section the median age of people in the United States was considered most appropriate, implying that severe storms and other natural disasters are equally likely to impact any age. The 6 percent curve from Cooper and Rice adjusted to 1977 dollars is presented on the facing page and it yields a value of approximately \$235,000 per life.

The value of an injury is less well defined, especially due to the nature of the injuries under consideration. Both the cost of treatment and the cost of lost wages must be considered in order to obtain a reasonable estimate. At this time, the necessary information is not available to make a reasonable estimate of the value of the injuries which would be most prevalent in severe storms.

HUMAN CAPITAL APPROACH TO THE VALUE OF A LIFE



ADAPTED FROM: COOPER AND RICE, THE ECONOMIC COST OF ILLNESS REVISITED, DHEW PUBLICATION NO. SSA 76-11703

SEVERE STORM WARNING SUMMARY

Improving the natural disaster warning system is likely to produce substantial social and economic benefits. The improvement in communications is most likely to reduce the number of human casualties and injuries. This study estimates that improved communications is likely to save 78 to 203 lives and to help avoid 901 to 2947 injuries.

Using the human capital approach to the value of a human life at \$235,000 the dollar benefit range is \$18.3 million to \$47.7 million when just the lives saved are considered. To these benefits must be added the value of injuries avoided and the value of reduced property damage.

SEVERE STORM WARNING SUMMARY

- WARNING SYSTEM POTENTIAL IMPROVEMENTS:

FORECAST

COMMUNICATION AND DISSEMINATION

RESPONSE

- MAJOR BENEFIT AREA FOR IMPROVED COMMUNICATIONS:

REDUCED HUMAN CASUALTIES - 78-203 LIVES SAVED

901-2947 INJURIES AVOIDED

HUMAN CAPITAL APPROACH TO LIVES SAVED (AT \$235,000/LIFE)

- BENEFIT RANGE FOR IMPROVED COMMUNICATIONS:

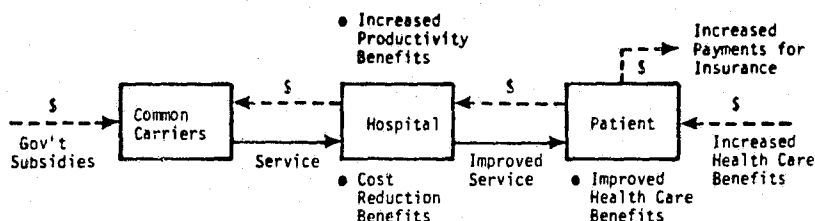
\$18.3M - \$47.7M

3. SUMMARY AND RECOMMENDATIONS

SUMMARY OF PRELIMINARY BENEFITS

The results of the preliminary benefit analyses are summarized on the facing page. For each application considered, the benefit types are indicated as well as the estimated magnitude of the annual benefits.

Prior to discussing the role of the preliminary benefit assessments in case study selection some general comments on benefits are in order. Different benefit types can and should have different impacts upon program justification and upon private sector decisions. Consider, for example, the effect of improved communications upon health services provided by hospitals, as illustrated below.



In this example, the impact of improved communications is such that the hospitals achieve cost reduction and increased productivity benefits and the patients receive increased health care benefits. A part of the cost reduction and increased productivity benefits will be used to pay for the communications service. If this is not adequate to cover the cost of the communications service, then it is necessary to receive payments, via the hospital, from the patients (a part of the improved health care benefits). The hospital utilization of the communication service will depend upon the ability of anticipated cost reduction and productivity benefits to pay for the communication service. It will also depend upon the ability to increase patient charges and the possibility of legislative action to increase hospital related budgets (i.e., government subsidies). An analysis of the demand for communications services must therefore consider the source of the derived benefits. Private sector demand analysis usually does not take into account social benefits--only cost savings and increased productivity benefits are considered.

The implication, from the private sector's point of view, is that there is a very disaggregate or highly uncertain market (when social benefits are dominant) which will only coalesce if legislation provides a requirement for funding. Even the demonstration (by NASA) of services and specific user involvement does not insure a market--it establishes the demand for services if funding (i.e., government subsidies) is available and provides added ammunition for those who wish to lobby for additional funding.

The last two columns on the facing page consider the capturability of benefits by other forms of communications services or other satellite communications systems (for example, SBS) and the estimated availability of data for performing case studies. For example, it is unlikely that other systems or services will provide the necessary communications services required in the emergency medical services applications because of the disaggregated nature of the market, the need for small mobile terminals, and the social category of benefits. Taken together, these factors focus attention on those applications most logical for selection as case studies.

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SUMMARY OF PRELIMINARY BENEFITS

| <u>APPLICATION</u> | <u>BENEFIT TYPE</u> | <u>MAGNITUDE OF ANNUAL BENEFIT</u> | <u>CAPTURABILITY OF BENEFITS BY OTHERS</u> | <u>ESTIMATED AVAILABILITY OF DATA FOR CASE STUDY</u> |
|----------------------------------|---|---|--|--|
| HEALTH SERVICES: | | | | |
| ● EMERGENCY MEDICAL SERVICES | SOCIAL (LIVES SAVED) | \$110-250M (5600-12300 LIVES) | LOW | HIGH |
| ● TELERADIOLOGY | RADIOLOGIST PRODUCTIVITY TRAVEL COST SAVINGS REDUCED HOSP. PAYMENTS REDUCED LOST WAGES | \$5 - 11M \$0 - 1M \$20 - 46M \$14 - 31M | LOW | HIGH |
| ● REMOTE CARDIAC MONITORING | COST SAVINGS | \$1M | LOW | HIGH |
| ● TELECONSULTATION | SOCIAL (MORTALITY RATE REDUCTION) | NEEDS FURTHER STUDY | LOW | MEDIUM |
| DATA TRANSFER: | | | | |
| ● NATIONAL NETWORK CONNECTIVITY | COST SAVINGS | \$18 - 190M | MEDIUM-HIGH | MEDIUM |
| ● NATIONAL COMPUTER BASED EDUC. | COST SAVINGS | \$11-2930M | LOW-MEDIUM | LOW |
| ● HIGH SCHOOL DROPOUT PREVENTION | SOCIAL | \$10 - 950M | LOW | LOW |
| ● ADULT EDUCATION | SOCIAL | \$ 0 - 9M | LOW | LOW |
| ● PRISON POPULATION EDUCATION | SOCIAL | \$ 0 - 3M | LOW | LOW |
| ● MEDICAL HISTORY RECONSTRUCTION | COST SAVINGS | \$10 -144M | LOW | HIGH |
| COM' EDUCATION FOR PROFESSIONALS | COST SAVINGS | \$17M | MEDIUM | MEDIUM |
| | COST SAVINGS + PRODUCTIVITY | \$180M | HIGH | MEDIUM |
| | COST SAVINGS SOCIAL (LIVES SAVED) | \$18 - 48M (78 - 203 LIVES) | MEDIUM | HIGH |

RECOMMENDATIONS FOR FY'78 ECONOMIC ANALYSES

Based upon the studies and analyses performed to date and the perceived NASA needs, it is recommended that economic analyses continue during FY'78. Specifically it is recommended that these efforts be devoted to case studies and an analysis of the private sector.

The purpose of the case studies is to establish benefit credibility by increasing sample size, scaling (generalization) accuracy and considering cost-effectiveness issues. The case studies would build upon the previous efforts eliminating their weaknesses and assumptions. In general, a major weakness of the previous studies is the small (in many cases one) sample size upon which the reported benefits are based. It is necessary to increase the sample size in order to gain an understanding of and have a high degree of confidence in establishing industry characteristics, methods, and operations. To generalize the benefit results it is necessary to establish scaling rules which are closer to the real world than those used in the preliminary benefit estimates. The accuracy and credibility of the generalization increases directly with sample size. A second major weakness of most of the benefit studies herein reported is that they establish the benefits of new and/or improved communications--they do not establish the benefits which may be derived from an operational PSCS system. This requires that issues of cost-effectiveness (i.e., other non-PSCS system alternatives be considered) be included as an integral part of the case studies.

It is understood that NASA intends to enter into Phase-B studies with one or more common-carriers who will offer to provide a set of public communications services to NASA. What set of services should be considered? Which proposed common-carrier approach is the best?* What data should be provided by the common-carriers so that NASA can select its best course of action? To help answer these questions it is recommended that an analysis of the private sector be initiated. Its purpose is to (a) determine public sector communications usage and estimate demand elasticities (i.e., effect of price changes on usage) in order to establish the demand which might result from price reductions, (b) to establish and analyze possible scenarios of private sector involvement in order to ensure that the Phase-B studies encompass all viable alternatives, and (c) to establish the methodology which NASA should employ to evaluate the common-carrier proposed alternatives and to establish the data requirements for this evaluation so that the data requirements may be included as part of the common-carrier work statements.

The case studies are aimed at establishing a credible and defensible program justification posture. The private sector analysis is aimed at insuring the selection of the best private sector-public sector scenario.

* It should be apparent that the least cost alternative is not necessarily the best alternative. The "best" alternative is that which maximizes the net benefits--this is in general not the same as minimizing costs (this is discussed in Appendix D).

RECOMMENDATIONS FOR FY'78 ECONOMIC ANALYSES

- CASE STUDIES

- ESTABLISH BENEFIT CREDIBILITY BY INCREASING SAMPLE SIZE, SCALING (GENERALIZATION) ACCURACY AND CONSIDERING COST-EFFECTIVENESS.

- PRIVATE SECTOR ANALYSIS

- DETERMINE PUBLIC SECTOR COMMUNICATION USAGE AND ESTABLISH DEMAND ELASTICITY

- ESTABLISH AND ANALYZE SCENARIOS OF PRIVATE SECTOR INVOLVEMENT

- ESTABLISH EVALUATION METHODOLOGY AND DATA REQUIREMENTS

CASE STUDY RECOMMENDATIONS

Based upon the results of the ECON preliminary benefit studies and considerations of benefit type, estimated annual benefit, the likelihood of other technologies and/or systems providing the required services, and the estimated availability of data being available, it is recommended that case studies be performed in the areas of Teleradiology, Emergency Medical Services, Teleconsultation, Medical History Reconstruction, and Continuing Education for Professionals. The preliminary benefit estimates have laid the groundwork for these. It is estimated that each of the first three case studies will require approximately 4 to 6 professional-months of labor and the latter two, because of the broader scope of the applications and the level of detail of the previous studies, will each require approximately 6 to 8 professional-months of labor.

It is recommended that case studies also be considered in the areas of Remote Maintenance, Law Enforcement (Public Safety) and Library Information Retrieval applications. Other (non-ECON) studies have indicated that potentially large benefits may be achieved in these applications from the use of PSCS provided services.

If the case studies are initiated in December 1977, preliminary results could be available in the spring of 1978 with final results available in the fall of 1978.

CASE STUDY RECOMMENDATIONS

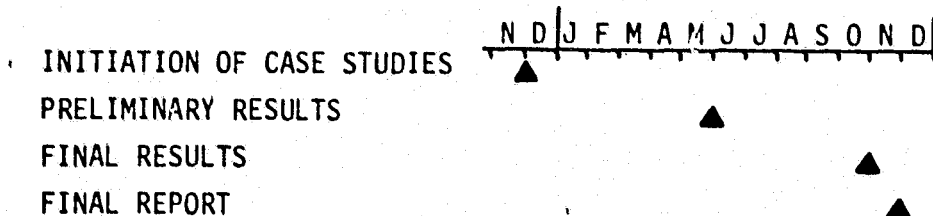
BASED UPON ECON RESULTS:

- TELERADIOLOGY 4-6 MM
- EMERGENCY MEDICAL SERVICES 4-6 MM
- TELECONSULTATION 4-6 MM
- MEDICAL HISTORY RECONSTRUCTION 6-8 MM
- CONTINUING EDUCATION FOR PROFESSIONALS 6-8 MM

OTHER AREAS FOR CASE STUDIES:

- REMOTE MAINTENANCE
- LAW ENFORCEMENT (PUBLIC SAFETY)
- LIBRARY INFORMATION RETRIEVAL

PROPOSED CASE STUDY SCHEDULE



PRIVATE SECTOR ANALYSIS

It is recommended that, in addition to the case studies, an analysis be performed of the private sector. The private sector analysis consists of two tasks, the first of which is an evaluation of demand elasticity and the second is an analysis of private-public sector scenarios. The purpose of the former task is to determine why public sector usage of communication services is limited and to estimate usage as a function of price. The purpose of the latter task is to establish likely possible private-public sector scenarios (for example, shared system versus NASA leased satellite system), determine the methodology which NASA should utilize in order to evaluate proposed scenarios (i.e., resulting from the forthcoming Phase-B studies), and to define data requirements for the scenario evaluation so as to ensure that the Phase-B studies will provide all of the data necessary for a thorough evaluation.

PRIVATE SECTOR ANALYSIS

- EVALUATION OF DEMAND ELASTICITY
(MARKET AND APPLICATION ANALYSIS)

PURPOSE IS TO DETERMINE WHY PUBLIC SECTOR USAGE
OF COMMUNICATION SERVICES IS LIMITED AND TO
ESTIMATE USAGE AS A FUNCTION OF PRICE

- DETERMINATION OF SCENARIOS WITH PRIVATE SECTOR
INVOLVEMENT (FOR EXAMPLE, SHARED SYSTEM VERSUS
NASA LEASED SYSTEM), DETERMINATION OF EVALUATION
METHODOLOGY, AND DEFINITION OF DATA REQUIREMENTS

PRIVATE SECTOR ANALYSIS

In order to illustrate the relationship of the proposed private sector analysis to the anticipated common carrier Phase-B studies, an anticipated schedule of events is shown on the facing page.

The demand elasticity task consists of a preliminary study of public service applications to pave the way for the market analysis. The market analysis should not be a survey. It should consist of an in-depth interview analysis where the interview is of sufficient depth so that user operations, methods and economics are understood and the results can be reliably extrapolated across the application sector. The "market analysis" should therefore yield sufficient information so that demand elasticities can be estimated, user "payback period" ascertained and the user demand established in terms of market characteristics (number of users, size of users, etc.) and payback period. This is elaborated upon in Appendix E.

The scenario analysis task consists of developing the set of interesting and likely private-public sector scenarios, establishing the evaluation methodology and the data which is needed in order to accomplish the evaluation. It is intended that both the demand elasticity and scenario analysis be completed prior to the initiation of the Phase-B studies by the common carriers. This will provide the carriers and NASA with a detailed understanding of the marketplace, and will provide NASA with the evaluation methodology and data requirements. In turn, these data requirements can be imposed upon the Phase-B contractors to assure that NASA can perform the appropriate evaluation.

The actual implementation of the evaluation methodology would take place during the time that the Phase-B studies are underway and the analysis of the Phase-B results would then take place upon completion of the studies and development (as part of the Phase-B studies) of the necessary data base.

PRIVATE SECTOR ANALYSIS

- DEMAND ELASTICITY

- PRELIMINARY ANALYSIS OF APPLICATIONS
- MARKET ANALYSIS
- ANALYSIS OF RESULTS
- APPLICATION ANALYSES
- REPORTING

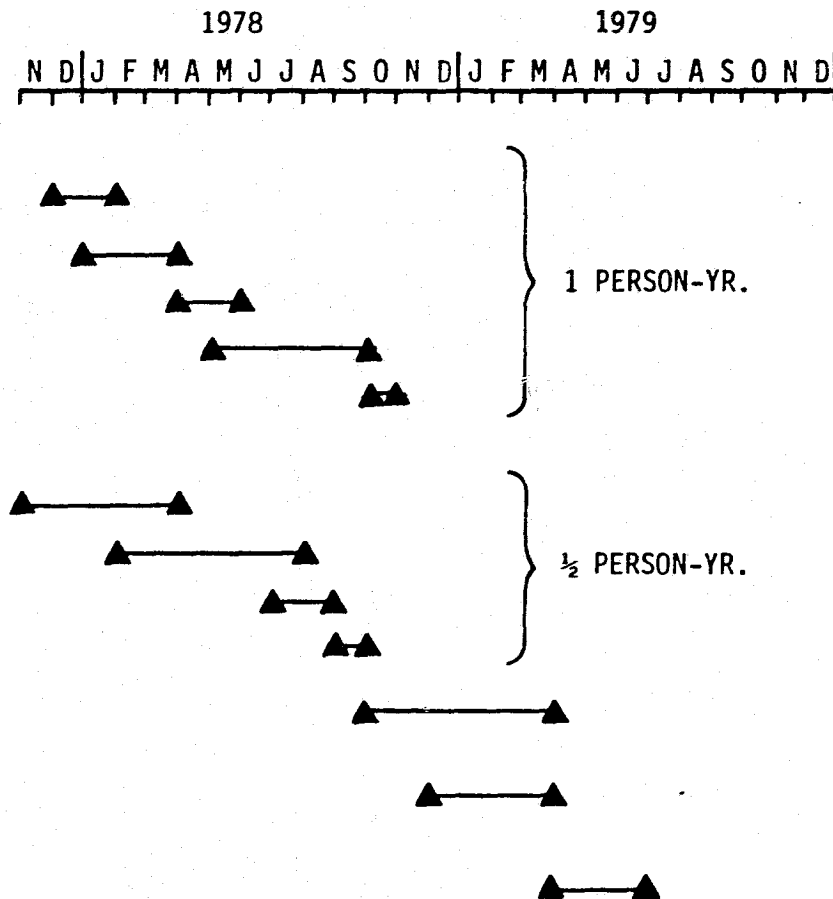
- SCENARIO ANALYSIS

- ANALYSIS OF SCENARIOS
- EVALUATION METHODOLOGY
- DATA REQUIREMENTS
- REPORTING

- PHASE-B STUDIES (CARRIERS)

- IMPLEMENTATION OF EVALUATION METHODOLOGY

- ANALYSIS OF PHASE-B STUDY RESULTS



APPENDIX A
FACSIMILE TRANSMISSION OF X-RAY IMAGERY

MEMORANDUM

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE

HEALTH SERVICES AND MENTAL HEALTH ADMINISTRATION
ALASKA AREA NATIVE HEALTH SERVICE, BOX 7-741

ANCHORAGE, ALASKA 99510

DATE: December 27, 1976

TO : Clinical Directors

FROM : Martha R. Wilson, M. D.

SUBJECT: Facsimile transmission of X-rays

It is now technically feasible to transmit X-rays over a conventional telephone circuit or a satellite audio circuit. During the course of our ATS-6 Experiment, we enjoyed a visit from Dr. Lewis Carey and Dr. Earl Russell who are Project Directors for one of the major CTS (Communication Technology Satellites). Both are from the University of Western Ontario Medical School where Dr. Carey is Chairman of the Department of Radiology and Dr. Russell is Chairman of Anesthesiology. They were quite pleased with the quality of films as recorded on tape by the full scale video.

We have remained in touch and Dr. Carey mentioned some months ago that some work was underway to modify the facsimile reproduction for transmitting satellite weather films in such a way to transmit X-rays.

Last week I received the attached information from Austin Cooley, the inventor of this device. The specifications, descriptions, a clinical paper (dated 1950) and copies of the original films and the facsimiles transmitted over the telephone are enclosed for your information. These facsimiles were transmitted at 50 line definition and required two and one-half minutes each. I talked to Mr. Cooley this morning and he indicates that they are not yet in production but he estimates that a custom-made send-and-receive unit could be made for \$25,000. A receive only would be about \$1,500. (I hope I understood that right.)

Another possibility to be explored is a slow-scan video in which at the sending end you simply point the camera at the X-ray on the view-box and it shows up on a television screen at the medical center. The quality of resolution is said to be quite good and potentially there could be other uses--the transmission of still pictures of patients for consultation purposes. A send-and-receive unit is estimated to be \$30,000-\$40,000. Such a unit is in use between Sells and Phoenix Indian Medical Center but I have had no experience with it. That unit is not in production yet either

I have shown these films and this correspondence to a number of the ANMC staff and they are all considering the ways in which such a device might be used. All felt that it would be useful in the management of emergencies. Dr. Holloway thought it would also be very helpful in follow-up of orthopedic problems.

Incidentally these transmissions will go at least as well by satellite as by telephone. Both Mr. Cooley and I would appreciate your comments. I will share your comments with all concerned, and, if you are interested, will try to obtain the funds needed for equipment, staff, maintenance, supplies, for a pilot project.

Martha R. Wilson, M.D.

COOLEY PROTOTYPE SERVICE

690 WEST SECOND STREET • RENO, NEVADA 89503 • (702) 322-0367

November 22, 1976

Dr. Martha Wilson
Indian Health Hospital
Anchorage, Alaska

Dear Dr. Wilson:

At the RSNA convention last week in Chicago, we exhibited films showing what can be done with our facsimile system designed to transmit from small hospitals to interpretation centers.

Dr. I.S. Carey of London, Ontario, told us of your interest in transmitting X-ray images in Alaska so we are enclosing for your information a sample recording together with the original film.

As described in the accompanying literature, the system operates over conventional telephone circuits that may be easier to obtain and less costly than video circuits.

In addition, the system delivers a hard copy with a density range of 0.2 to 3.0 or nine log 2 density steps as compared with about five for a video system.

It may be of interest to you to know that the pioneer work for this system included transmission of pictures from Fairbanks to Slingerlands, N.Y., in 1941 with Augie Hiebert of KTVB at the transmitting end.

The work on this system is now ready to turn over to an established organization that will put it into production. Your interest and comments may be very helpful to us in talking with prospective manufacturers.

Very truly yours,

Austin G. Cooley
Austin G. Cooley

RAYFAX

Roentgen-ray Facsimile

(Telognosis)

An X-ray film can be transmitted unlimited distances in five minutes on **RAYFAX** equipment.

Displayed at this exhibit are films processed through a prototype system. Operationally, this is a practical method of reducing to near zero the time now required in traveling to the hospitals and clinics you serve.

RAYFAX

There probably will be a RAYFAX in your future. Now is a good time to learn something about the specifics.

RAYFAX has been designed to transmit X-ray films over telephone lines or radio. Its use will assure you, the radiologist, of full and gainful time spent in your most important area: viewing and reporting. You eliminate travel time and interruption to your normal routine.

SYSTEM DETAILS

| | |
|--|--|
| Transmission Time at 50 Line Definition 14" x 17" films | Five minutes |
| Transmission Time at 100 Line Definition 14" x 17" films | Twenty minutes |
| Circuit | Substantially all telephone lines. |
| Distance | No limit when operating over a modern telephone facility. |
| Cost of Circuit | Same as for voice. The night rates are now minimal. |
| Cost of Transmitter (Estimate) | \$10,000 |
| Cost of Recorder (Estimate) | \$10,000 |
| Rental of either Transmitter or Recorder with Maintenance (Estimate) | \$350 per month |
| Picture Definition | 50 lines per inch or 100 lines per inch. The 50 line definition is satisfactory for most films. All films shown in this exhibit were scanned at the 50 line rate. |
| Scanning Density | From 0.2 to 3.0 |
| Recording Density | From 0.2 to 3.0 |

Recording Tolerances

Variations between .3 density steps less than .1. In other words, this means that to the eye, the recorded film will follow the appearance of the original so closely the facsimile will be as easy to read as the original.

Automatic Load

100 films of sizes between 8" x 10" and 14" x 17" can be loaded into a hopper and transmission will start at a designated time, preferably when phone rates are low.

Automatic Operation

The transmitting operator need only push a start button or set a timer after loading a hopper with films. Recorded films then may be processed in a conventional X-ray film processor. If there is the demand, a processor will be made for automatically developing the films immediately after recording.

Line Power

115 \pm 10 volts Ac.
Approximately 300 watts

Transmitter Size

Front 40 inches; depth 30 inches, height of equipment above desk top 20 inches.

Weight

Approximately 75 pounds not including desk.

Recorder

This will be procured from one of three manufacturers who are supplying them to the press services. Minor modifications will be required.

Do you visualize a RAYFAX system to improve your services? Would you have a requirement for a system to transmit films in less than a minute and at high definition in a hospital or at distances of a few miles?

We are now ready to negotiate for the manufacturing and marketing of RAYFAX with an organization established in the field of radiology.

Cooley Prototype Service
690 West Second Street
Reno, Nevada 89503
Telephone: (702) 322-0367

HISTORY OF RAYFAX

Field tests of Roentgen-ray Facsimile under the guidance of Dr. J. Gershon-Cohen were initiated in 1948 by Times Facsimile Corporation. Satisfactory transmission of X-ray films over both telephone and radio facilities has been accomplished under actual conditions encountered in practice. The first circuit was placed in operation in 1948 between the Chester County Hospital at West Chester, Pa., and Dr. Gershon-Cohen's office in Philadelphia. Other circuits were established between Dr. Gershon-Cohen's office and Newcomb Hospital, Vineland, N.J.; Ventnor Clinic, Atlantic City, N.J., and Jewish Hospital, Philadelphia, Pa. Many other circuit tests were made with results satisfactory to the radiologist.

A highly satisfactory radio test for the U.S. Air Force in January 1956 was made by transmitting films from Griffis Air Force Base, Rome, N.Y., to Press Wireless receiving facilities at Baldwin, Long Island, N.Y.

Equipment did not go into production because the economics were unfavorable due largely to high telephone rates at that time; and operating technician labor costs, which have been eliminated with RAYFAX.

The system as it first appeared, under the name of Telognosis, is described in Radiology, October 1950. A reprint is available at Booth 1345.

APPENDIX B
LAWYER POPULATION

| | 1971 Lawyer Statistical Report | New Admittees 1970-75 | 1975 ABA Estimate-- Lawyer Population |
|-------------------------|---|--------------------------|--|
| Total | 355,242 | 161,677 | 425,039 |
| Alabama | 3,537 | 1,402 | 4,800 |
| Alaska | 466 | 462 | 904 |
| Arizona | 2,769 | 1,985 | 3,903 |
| Arkansas | 2,107 | 934 | 3,425 |
| California | 34,248 | 21,553 | 42,484 |
| Colorado | 4,665 | 3,097 | 6,577 |
| Connecticut | 5,583 | 2,267 | 5,800 |
| Delaware | 736 | 288 | 850 |
| District of Columbia | 16,112 | 3,921 | 8,600 |
| Florida | 11,510 | 8,750 | 15,800 |
| Georgia | 6,140 | 4,027 | 8,000 |
| Hawaii | 906 | 796 | 1,400 |
| Idaho | 848 | 467 | 1,078 |
| Illinois | 22,036 | 8,158 | 26,012 |
| Indiana | 5,778 | 2,741 | 6,500 |
| Iowa | 4,020 | 1,865 | 3,800 |
| Kansas | 3,458 | 1,575 | 3,593 |
| Kentucky | 3,875 | 1,633 | 5,000 |
| Louisiana | 5,502 | 2,706 | 7,096 |
| Maine | 1,130 | 658 | 1,500 |
| Maryland | 7,447 | 3,273 | 9,000 |
| Massachusetts | 12,905 | 5,936 | 16,095 |
| Michigan | 11,926 | 4,999 | 14,450 |
| Minnesota | 5,844 | 2,500 | 7,200 |
| Mississippi | 2,766 | 1,314 | 3,100 |
| Missouri | 7,962 | 3,072 | 8,209 |
| Montana | 1,072 | 406 | 1,200 |
| Nebraska | 2,679 | 1,370 | 3,100 |
| Nevada | 773 | 498 | 1,124 |
| New Hampshire | 823 | 438 | 1,122 |
| New Jersey | 11,999 | 6,148 | 15,499 |
| New Mexico | 1,319 | 891 | 1,750 |
| New York | 55,946 | 16,429 | 64,000 |
| North Carolina | 4,638 | 2,177 | 7,200 |
| North Dakota | 809 | 325 | 693 |
| Ohio | 17,001 | 6,584 | 18,782 |
| Oklahoma | 5,056 | 1,921 | 5,638 |
| Oregon | 3,207 | 1,914 | 4,308 |
| Pennsylvania | 14,418 | 8,081 | 17,800 |
| Rhode Island | 1,390 | 488 | 1,300 |
| South Carolina | 2,379 | 1,281 | 2,900 |
| South Dakota | 826 | 366 | 873 |
| Tennessee | 5,184 | 2,150 | 7,000 |
| Texas | 19,074 | 8,903 | 24,779 |
| Utah | 1,367 | 712 | 1,850 |
| Vermont | 611 | 351 | 800 |
| Virginia | 6,893 | 3,421 | 7,880 |
| Washington | 4,671 | 2,765 | 6,800 |
| West Virginia | 1,820 | 672 | 2,156 |
| Wisconsin | 6,697 | 2,710 | 7,609 |
| Wyoming | 475 | 295 | 500 |

Source: American Bar Association.

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APPENDIX C
SATELLITE EXPERIMENTS IN CLE

APPENDIX C

SATELLITE EXPERIMENTS IN CLE

1. Hastings School of Law Experiment

A General Description

On Saturday, January 29, 1977, a unique experiment in legal education took place in California.

Utilizing a communication satellite and terrestrial microwave and ITFS interlinkages, a day-long program of demonstrations and correlated lectures in civil and criminal trial practice was broadcast live to law schools throughout California.

Of the 550 lawyers and law students participating in the program, 96.7 percent indicated they would be interested in attending similar programs in the future.

The five-hour presentation originated from the moot courtroom of Hastings College of the Law in San Francisco and was relayed by the Communications Technology Satellite to six other law schools in California. At each reception site, participants viewed the program on a closed-circuit television system and were able to submit questions that were relayed to the origination site at Hastings by telephone. The Hastings Alumni Association provided personnel at each reception site to coordinate questions from participants.

The program followed a trial format from jury selection to closing arguments and the Faculty was selected from among the leading judges, trial lawyers and legal educators in the State.

The program was modeled on the nationally-acclaimed College of Advocacy, an intensive one-week course in trial advocacy presented each summer by Hastings College of the Law.

Early in January, 35,000 brochures were mailed to attorneys throughout California inviting them to attend the program at law schools in Davis, Sacramento, Berkeley, Santa Clara, Palo Alto and Los Angeles as well as at the origination site in San Francisco. A tuition of \$30.00 was charged to practicing attorneys; law students and law school faculty were invited to attend without charge. The Hastings Alumni Association co-sponsored the event and members of the Association were charged a lower tuition of \$20.00.

This cooperative effort between NASA, Hastings College of the Law and the University of California was unique in the field of continuing legal education and will serve as a model for subsequent endeavors in the utilization of satellite technology to serve the educational needs of the legal community.

Description of the Television Broadcasting System

Television coverage of the program at Hastings was provided through the facilities of the Educational Television Office of the Berkeley campus of the University of California. The video and audio signals were transmitted from Hastings, via microwave, by the Pacific Telephone and Telegraph Company to the satellite up-link at NASA/AMES in Mountain View. The Earth Transmission Terminal at NASA/AMES relayed the signal to the Communications Technology Satellite.

The signal from the satellite was received by fixed earth reception terminals at California State University at Chico, the San Francisco Archdiocese ETV Center at Menlo Park and by a portable earth terminal at the University of California at Los Angeles.

From the Chico Earth Terminal the signal was transmitted by microwave to the Davis campus of the University of California and fed through the campus closed-circuit television system to the Moot Courtroom of the School of Law on the Davis campus.

At Davis the signal was also relayed through the campus ITFS System to the University's Sacramento Medical Center ITFS repeater and thence to an ITFS reception terminal at the University of the Pacific's McGeorge School of Law in Sacramento.

From NASA/AMES in Mountain View the signal was broadcast via microwave to Stanford University in Palo Alto. At Stanford the signal was fed into the University's closed-circuit television system. At Stanford, the signal was also relayed, via ITFS, to the Berkeley campus of the University of California where it was fed through the campus closed-circuit system to large television classrooms in Dwinelle Hall.

From the Menlo Park Earth Terminal, via ITFS, the signal was sent to the School of Law at the University of Santa Clara and shown in television classrooms connected to the campus closed-circuit television system.

In Los Angeles the satellite signal was received by a portable earth terminal supplied by the Westinghouse Electric Corporation. The terminal was sited at the UCLA campus. The signal was then fed, via the campus closed-circuit TV system, to the Law School and an adjacent classroom building.

Written questions from participants at remote sites were collected at each site and relayed by telephone to Hastings and answered over the system during question periods scheduled in the program.

Technical Assessment of the Broadcasting System

The satellite downlink at California State University at Chico failed to receive a usable signal when the broadcast began at 10:15 a.m. Although

some usable signal was transmitted from Chico between 11:14 a.m. and 3:30 p.m., until 1:00 p.m., videotape cassettes were substituted for the live presentation at the Davis Law School site and the McGeorge Law School site. Most of the participants at these two sites left when it seemed that the live broadcast would not be available. Those who stayed at the McGeorge site watched the last half of the origination from 1:10 p.m. until 3:30 when the equipment malfunction at Chico was rectified.

Other than the failure of the terminal at Chico and the subsequent loss of signal at Davis and McGeorge, the broadcasting system functioned well, and the technical quality of video and audio signals at each of the other four sites was excellent.

The Audience

The total number of participants at all of the sites was 550. Questionnaires were passed out at five sites, and a total of 287 questionnaires were returned.

The following assumptions are based on analysis of those 287 questionnaires.

The target audience was to be practicing attorneys and law students. 68.7 percent of the audience were practicing attorneys, 27.3 percent law students, and 4 percent others. 31.7 percent of the attorneys considered themselves specialists in the area of civil trial practice. 50.3 percent of the attorneys did not consider themselves to be specialists.

A high percentage of the attorneys (71.9 percent) had been in practice for less than five years, and only 25 percent of the total had not attended at least one continuing legal education program in 1976.

Expenses and Revenue

Practicing lawyers participating in the program were charged a fee of \$30.00 each.

Hastings Alumni were charged a lower fee of \$20.00 because the Hastings Alumni Association provided coordination personnel at each reception site and acted as a co-sponsor of the program.

Two hundred eighty regular registrations provided \$8,400 and 66 alumni registrations totaled \$1,320.

In addition to the total income of \$9720 from participant fees, the project received a generous grant of \$5,000 from the Systemwide Administration of the University of California.

The total expenses for the program amounted to \$15,009.44 against revenue of \$14,720.00 and the final result was a deficit of \$289.44. Details of the expenses and revenue are itemized in the budget section of this Appendix.

Because of unanticipated delays, the publicity brochures for the program were not mailed until the first week in January. An informal survey of attorneys in the Bay Area and Southern California indicated that the brochures may not have been received by most of the potential participants until the end of the second week in January. Perhaps, had brochures been mailed earlier, the number of lawyers attending the program would have been sufficient to offset all of the costs by registration fees alone.

Conclusion

The enthusiastic response of the audience to "The Best of Advocacy 1977," as evidenced in the evaluation questionnaire, will certainly encourage more uses of satellite communications in continuing legal education.

The ability and willingness of the users to pay fees to partly offset the costs of the program will make future uses of satellites in this field financially viable.

Indeed, continuing professional education in many disciplines can benefit from the results of this experiment. Presently two programs in Public Health and City Planning, to be broadcast on a Western regional basis, are in the early stages of development.

For this experiment, continuing legal education seemed a logical choice in view of the experience of Hastings in presenting programs by television. The experiment was a response to a growing need for continuing legal education both on state and national levels. Within the past few years, on a state-by-state basis, there has been a trend toward certification of specialties in the practice of law and mandatory continuing legal education is a reality in two states.

It is expected that this trend will continue and the communication satellite may well be the most effective delivery system for continuing legal education programs in the future.

BUDGET REPORT

EXPENSES

Television Production Costs

| | |
|--------------------------------------|--------------------|
| Labor (planning and production crew) | \$ 4,210.75 |
| Television facilities | <u>531.00</u> |
| TV Production Subtotal | <u>\$ 4,741.75</u> |

Satellite Receiving Terminals & Microwave Interconnections

| | |
|--|--------------------|
| Westinghouse Electric Corp. (for portable CTS ground terminal) | \$ 2,285.00 |
| Stanford University (TV services) | 200.00 |
| Pacific Telephone (audio and video facilities; Hastings to NASA/AMES) | 1,849.00 |
| Educational TV Center, San Francisco Archdiocese (TV transmission services) | 550.00 |
| UCLA (TV services) | 500.00 |
| UC/Davis (TV services) | <u>391.70</u> |
| Terminal and Inter- connection Subtotal | <u>\$ 5,775.50</u> |

Miscellaneous Expenses

| | |
|------------------------------|------------------|
| Secretarial/telephone/travel | \$ 650.93 |
| Graphics | <u>161.26</u> |
| Subtotal | <u>\$ 812.19</u> |

Questionnaire

| | |
|-------------------------|------------------|
| Printing | \$ 28.80 |
| Tabulation/computer run | <u>93.00</u> |
| Subtotal | <u>\$ 121.80</u> |

Brochure

| | |
|--------------------------------------|--------------------|
| Printing | \$ 1,051.00 |
| Postage, preparation & mailing lists | 1,458.00 |
| Photography/artwork | <u>50.00</u> |
| Subtotal | <u>\$ 2,559.00</u> |

On-Site Coordination & Associated Expenses

| | |
|--|------------------|
| Labor and Down Site expenses (staffing/travel) | \$ 946.00 |
| Shipping of back-up tapes | 14.00 |
| General postage | <u>39.00</u> |
| Subtotal | <u>\$ 999.00</u> |

REVENUE

| | |
|---|--------------------|
| Grant from Systemwide Administration of the University of California | \$ 5,000.00 |
| Revenue from Registration | |
| 345 net paid registrations (6 cancellations, 12 refunds) | |
| 280 regular registrations @ \$30/each | 8,400.00 |
| 66 alumni registrations @ \$20/each | <u>1,320.00</u> |
| Registration Subtotal | <u>\$ 9,720.00</u> |
| TOTAL REVENUE | <u>\$14,720.00</u> |

2. Moot Court Experiment

telecom update

REPORT FROM THE TELECOMMUNICATIONS OFFICE OF THE MARYLAND CENTER FOR PUBLIC BROADCASTING

SPRING 1977

CENTER'S SPACE AGE MOOT COURT A SUCCESS

- After nearly a year in planning, the Telecommunications Office's moot court satellite competition was successfully held in the teleconference facilities of the Westinghouse Electric Corporation in Baltimore and Lima, Ohio. Five hundred miles apart, law students Robert Kershaw and Peter Parvis, University of Maryland, faced James Piampiano and William Evenson, Ohio Northern University law students.



Robert Kershaw, University of Maryland, delivers argument to four judges, two of whom are 500 miles distant.

Linked in space by the powerful Communications Technology Satellite, which hovers 22,300 miles above the Equator, the two teams argued a case involving a stock offer in the mythical state of "Northwest." Each oralist in the competition faced four judges—two "live" and two appearing on life-size projected color television screens. Acting as competition judges for the moot court in Maryland were Judge Joseph F. Weis, Jr., Federal judge for the Third Circuit Court of Appeals, Pittsburgh, and Howard Primer, project director of the American Bar Association's Committee on Technology and the Courts. The judges in Ohio were Dean Albert Baillis and Professor Bruce Rockwood, Ohio Northern University. Any one of the four judges was able to interrupt and question each oralist at any time; distance and technology were not factors.

While no opinions were offered on the case, the judges joined oralists and spectators in a long-distance evaluation of the potential of satellite technology for future use in the world of law. Said Judge Weis, "I can see communications satellites improving the functioning of the courts in widespread circuits." Primer added, "With the advent of international law, satellite communication can become vitally important."

The moot court satellite competition is one of a series of short-term satellite demonstrations planned by the Maryland Center's Telecommunications Office. The objectives are to demonstrate developing technology and particularly to give direct experience with satellite communications to a variety of potential users.

John H. Nunnally, Westinghouse Electric Corporation, was responsible for making available the Westinghouse earth stations and satellite teleconference facilities as part of a continuing Westinghouse/NASA experiment. For the University of Maryland, Professor Alan Hornstein and Andrew Caffey coordinated the planning efforts of the School of Law.



John H. Nunnally (center), Principal CTS Investigator for Westinghouse, and Dr. Arthur Kahn (right), Westinghouse Advisory Psychologist, visit Maryland Center's Telecommunications Office to evaluate effectiveness of demonstration.

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APPENDIX D

SELECTION OF ALTERNATIVES

APPENDIX D

SELECTION OF ALTERNATIVES

The public sector should generally invest in an R&D program if it can be shown that the present value of the benefits which may be derived as a result of the R&D program exceed the present value of the cost of the R&D program. Benefit-cost analysis is concerned with evaluating the benefits and costs. The benefits and costs are those that would be realized by society and include the benefits received and costs incurred by members of society who are direct parties to the resulting market transactions (for example, the provider and user of a communications service) as well as those who are not direct parties to the market transaction but who are indirectly affected.* Thus, when the public sector makes an investment, the anticipated benefits must exceed costs.

When it is possible that a set of objectives can be achieved by pursuing one of a number of alternatives, it is necessary to establish a rationale for selecting that alternative which is best. Given that each alternative is reasonable from the point of view of budgetary constraints it is then necessary to select that alternative which is best. The objective should be to select that alternative which maximizes net benefits (present value of benefits less costs). Note that, in general, this is different than

* For example, improved communications services may increase both the effective skills and productivity of teachers. The increased productivity leads to cost savings benefits and the increased skill leads to increased capability benefits to the students or recipients of improved education. The teachers (i.e., the school system) are the direct parties to the market transaction through their purchase of the communications service, whereas the students are not direct parties to the market transaction.

selecting that alternative which minimizes costs.* The following paragraphs present a simplified hypothetical example, based upon the alternatives which may result from the PSCS Phase-B studies and which illustrates the difference between selecting an alternative based upon maximizing net benefits rather than minimizing costs.

Let it be assumed that a set of requirements is provided by NASA to the Phase-B contractors. Let it be assumed that the Phase-B contractors respond by specifying ground terminal costs and connectivity costs. Note that for the sake of simplification such items as duration of lease guarantee, duration of applicability of connectivity cost, and duration of service guarantee are not considered. Let it further be assumed that a number of different communications services are to be offered, with each having different requirements for ground terminal configuration and channel capacity.

With these assumptions and limitations in mind it can be seen that

Total Annual Cost = f{number of ground terminals of each type,
number of channels for each service type,
connectivity cost per service type, annual
lease rate per terminal of each type}

Annual Benefits** = f{number of installed ground terminals of
each type, annual direct benefits achieved
through use of each type of ground terminal}

Number of
Installed Ground
Terminals = f{number of ground terminals procured of each
type, annual lease rate per terminal of each
type, connectivity cost per service type, annual
direct benefits achieved through use of each
type of ground terminal}.

* Note that if it is desired to select an alternative which minimizes project costs, then the alternative selected should be to do nothing since this reduces costs to zero.

** Assumed steady state.

These functional relationships may be written in the following simplified form:

$$TAC_J = \sum_I [M'_{I,J} * L_{I,J} + M'_{I,J} * N_I * C_{I,J}] \quad (1)$$

$$BEN_J = \sum_I B_{I,J} * M_{I,J} \quad (2)$$

$$M_{I,J} = U_I * \left[1 - \exp \left(- \frac{K * B_{I,J}}{L_{I,J} + C_{I,J}} \right) \right] \quad (3)$$

$$NB_J = BEN_J - TAC_J \quad (4)$$

where I = index referring to terminal type

J = index referring to NASA alternative (i.e., each of the Phase-B contractor proposals)

TAC = total annual cost

M' = number of procured ground terminals

M = number of terminals utilized

N = effective number of channels

L = annual lease rate

C = annual connectivity cost

BEN = total annual benefits

B = annual benefits per terminal

U = total user population which may desire to utilize the communication terminal of type I

K = constant

NB = net benefits.

Equations 1, 2 and 4 are self-explanatory. Equation 3 is an assumed relationship which states that the number of users who will ultimately utilize the ground terminal is related through a nonlinear relationship to "payback period." Payback period is $(K * B)/(L + C)$.

In order to illustrate the implications of this simple model the following numerical example is considered.* Let

$$B_{1,1} = B_{1,2} = 5000$$

$$B_{2,1} = B_{2,2} = 10000$$

$$U_1 = 1000$$

$$U_2 = 100$$

$$N_1 = N_2 = 1$$

$$K = 0.1$$

This implies two different ground terminals each yielding different benefits and having applicability to different user populations. The following results are thus obtained, when the communication costs ($L + C$) are as indicated, for two alternatives ($J = 1$ and $J = 2$). Note that

| Alternative | Terminal Cost ($L_{1,J} + C_{1,J}$) | | Total Annual Cost, TAC_J | Total Annual Benefits, BEN_J | Net Benefits, NB_J | Number of Terminals Utilized | |
|-------------|--|------|-------------------------------|-----------------------------------|-------------------------|---------------------------------|-----------|
| | 1 | 2 | | | | $M_{1,J}$ | $M_{2,J}$ |
| 1 | 2000 | 7000 | $.536 \times 10^6$ | 1.24×10^6 | $.704 \times 10^6$ | 221 | 13 |
| 2 | 4000 | 1000 | $.533 \times 10^6$ | 1.22×10^6 | $.686 \times 10^6$ | 118 | 63 |

the more costly alternative (#1) yields the largest net benefits. Also note the number of terminals demanded ($M_{1,J}$ and $M_{2,J}$) by potential users.

Consider now the situation where NASA desires to enter into a contract which would result in the procurement of $M'_{1,J}$ ground terminals. Again to illustrate with numerical results, let $M'_{1,J} = 150$ and $M'_{2,J} = 40$. It should be noted that for alternative 1 in the above table, an insufficient quantity of terminals of type 1 and an excess of terminals of type 2 will

*The values used are purely arbitrary and have been selected to demonstrate a point and not to indicate potential values applicable to PSCS.

have been procured. If alternative 2 is pursued, an insufficient quantity of terminals of type 2 and an excess of terminals of type 1 will have been procured. The results of the procurement constraint are illustrated below. The total annual cost includes the lease and connectivity costs (assumed to

| Alternative | Terminal Cost ($L_{1,J} + C_{1,J}$) | | Total Annual Cost, TAC_J | Total Annual Benefits, BEN_J | Net Benefits, NB_J | Number of Terminals Utilized | |
|-------------|--|------|-------------------------------|-----------------------------------|-------------------------|---------------------------------|-------------|
| | 1 | 2 | | | | $M_{1,J}$ | $M_{2,J}$ |
| 1 | 2000 | 7000 | $.580 \times 10^6$ | $.880 \times 10^6$ | $.300 \times 10^6$ | 150 (150)* | 13 (40)* |
| 2 | 4000 | 1000 | $.640 \times 10^6$ | $.990 \times 10^6$ | $.350 \times 10^6$ | 118 (150)* | 40 (40)* |

*Terminals procured.

be guaranteed by NASA) for the procured but not utilized terminals. Again it should be noted that the situation can arise where selection of the lowest cost alternative ($J = 1$ in this case) is not the correct solution since the higher cost alternative ($J = 2$ in this case) maximizes the net benefits.

Thus, through the use of hypothetical numeric examples, it has been demonstrated that the least cost alternative does not necessarily lead to the maximization of net benefits. It is the maximization of net benefits which is the correct goal for the selection of public sector R&D alternatives. It is clear that in order to pursue the goal of net benefit maximization it is necessary to consider both benefits and costs as well as their interactions.

While cost has not been considered as a constraint in this example, it could also be shown that with a ceiling on costs, the minimum cost system does not necessarily maximize the benefits.

APPENDIX E

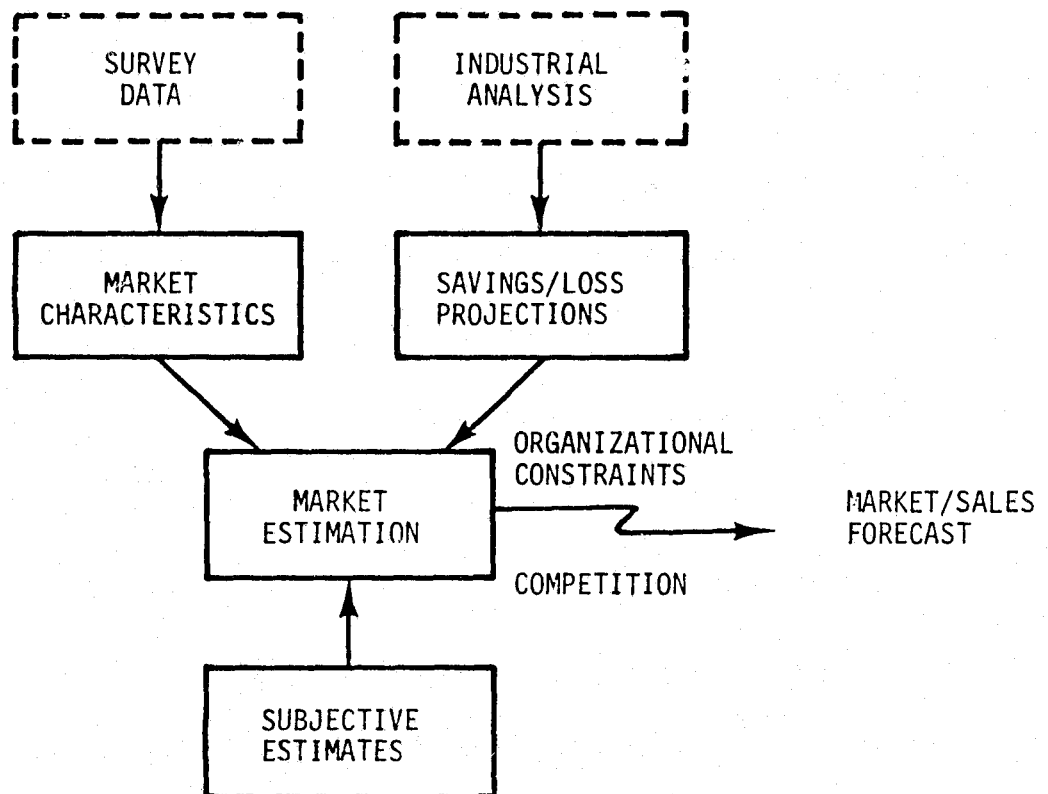
MARKET ESTIMATION

MARKET/SALES FORECAST METHODOLOGY

The methodology to be described is applicable when the desire to purchase a product or service depends primarily upon the estimation of the savings that might result from the utilization of the product or service. To estimate the market potential it is necessary to know the number of organizations or firms which comprise the applicable sectors of the economy, and such things as their profit, sales volume, net worth, and purchasing characteristics. It is also necessary to know the number of organizations or firms in terms of their production level (i.e., number of emergency medical cases per day, number of students per day, etc.). This data can be obtained via surveys. It is also necessary to have reliable estimates of the saving or loss that would result from the use of the new product or service in terms of the production level--this requires an industrial analysis. Subjective estimates must be made which relate to the likelihood of acquisition and use of the new product or service to savings or loss. In essence, the subjective estimates result in the probability of purchase as a function of time and as a function of payback period.

The methodology described in the following pages has been used on numerous occasions to estimate demand as a function of price and as a function of time. The methodology is predicated upon understanding of user requirements and methods and procedures of operations, and the impact of the new product or service upon the methods and procedures of operations.

MARKET/SALES FORECAST METHODOLOGY



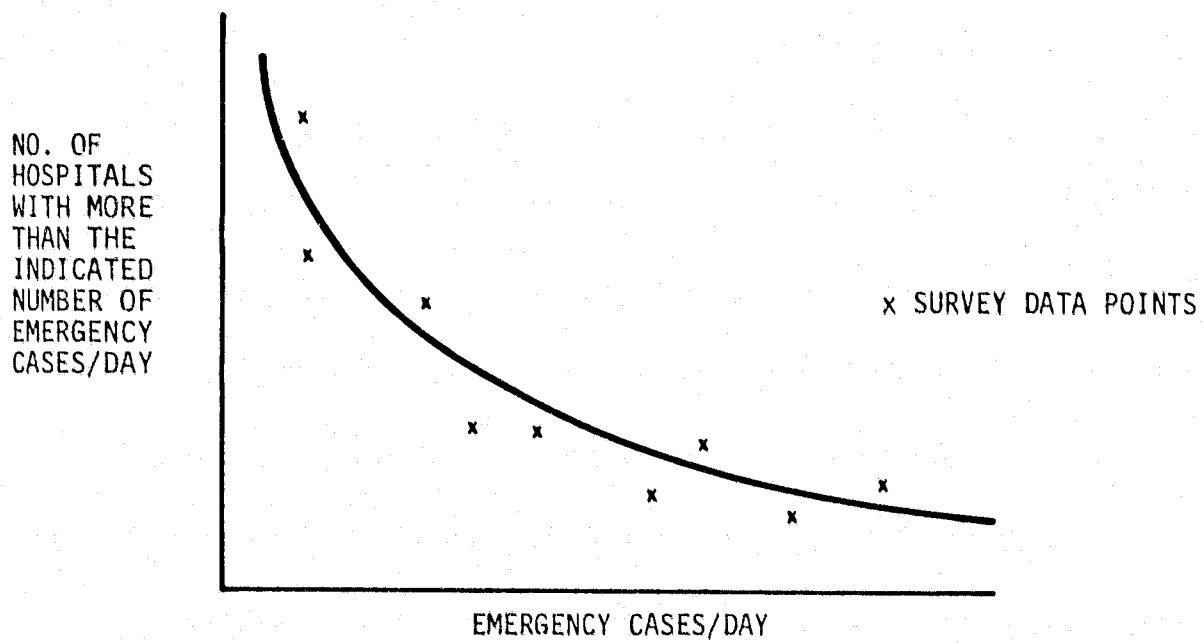
MARKET CHARACTERISTICS

A properly constructed market survey can provide reliable information pertaining to market characteristics. The survey (for example, telephone interview) should not ask questions such as: Would you buy the new product or utilize the new service? The survey should be designed to yield as a primary output (after extrapolation of results) the number of establishments versus production level. An example for communications for hospital emergency medical services is illustrated on the facing page. The survey should gather quantitative, not qualitative, data. Typical questions asked should pertain to number of employees, production level, current equipment mix, time per unit processed, and wage rates.

The market should be segmented as finely as possible--for example, by SIC category and by number of employees or rural and urban hospitals. The form of the results of a market survey are illustrated in terms of the number of establishments having greater than specified production levels.

Any market survey that is performed should sample a large enough group of each market segment (typically >10 percent) so that reasonable projections can be made. There is, of course, a trade-off between reliability or confidence of projections and the cost of obtaining the data.

MARKET CHARACTERISTICS



INDUSTRIAL ANALYSIS
--PAYBACK PERIOD IN TERMS OF PRODUCTION LEVEL--

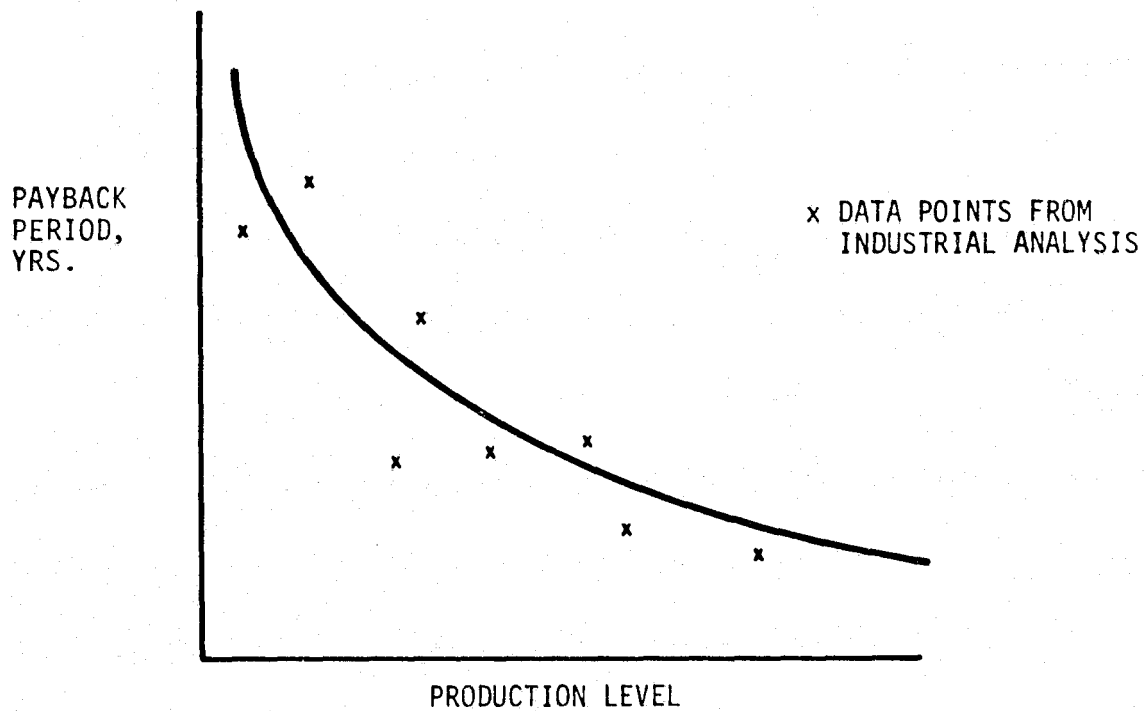
An industrial analysis is an in-depth analysis of the procedures and costs of operations which would be affected if the product or service under consideration was acquired. The purpose of the industrial analysis is to obtain the current system costs based upon the current methods of doing business. The current system costs include such things as labor, materials, depreciation expenses, and facilities cost. An analysis, with management's cooperation (management is normally very helpful and cooperative when assisting with the planning of new products and/or services), will lead to estimates of the annual cost of a proposed system--a proposed system in terms of the utilization of the new product and/or service. The annual cost of the current and proposed systems results in the annual savings or loss. This, taken together with the purchase price of the new product and/or service and salvage value of existing equipment results in payback period.

$$\text{PAYBACK PERIOD} = \frac{\text{CAPITAL EXPEND.} - \text{SALVAGE VALUE}}{\text{INCREMENTAL CASH FLOW}}$$

$$\text{INCREMENTAL CASH FLOW} = \left[1 - \frac{\text{TAX RATE}}{100} \right] \times [\text{CURRENT SYS. COST} - \text{NEW SYS. COST}] + \text{NEW SYS. DEPREC.} - \text{CURRENT SYS. DEPREC.}$$

If the industrial analysis is performed at various-size (production level) establishments, then projections of payback period in terms of production level can be established as indicated on the facing page.

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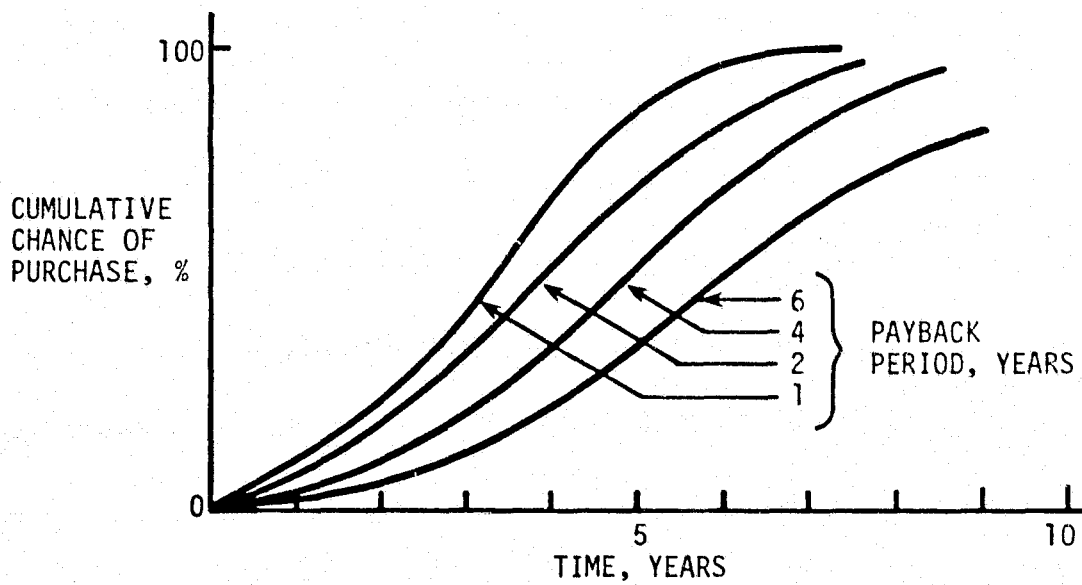
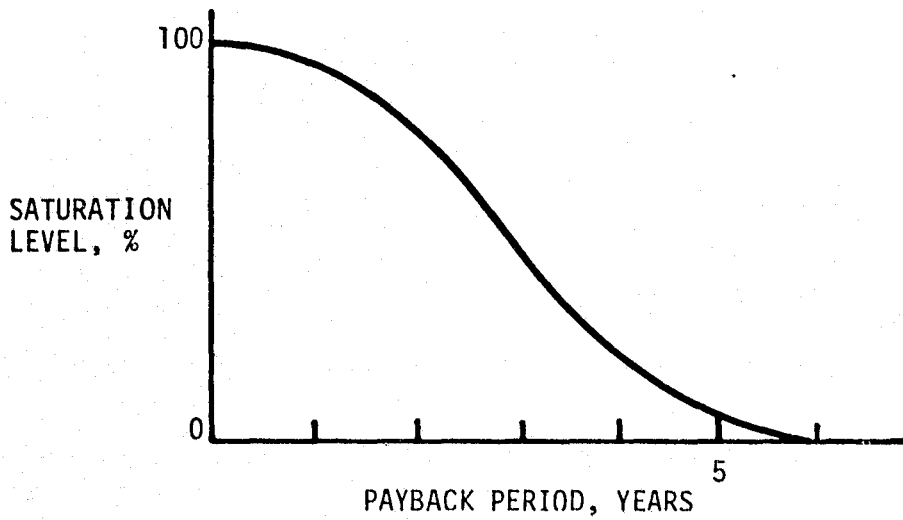


SUBJECTIVE ESTIMATES

Subjective estimates can be broken down into two areas, the saturation level and the cumulative chance of acquisition or purchase. Saturation level is defined as the fraction of the establishments which will ultimately acquire the new product or service. Note that saturation level is a function of payback period. The next question to be answered is the rate at which the new product or services will be acquired. This requires estimating the chance of acquiring the product or service as a function of time and as a function of payback period. Note that both saturation level and probability of acquisition or purchase are related to payback period. Short payback period implies high saturation level and rapid rate of growth to the saturation level. Long payback period implies low saturation level and low rate of growth to the saturation level.

Note that very specific subjective estimates have been defined. These estimates may be made by individuals, or groups of individuals (using Delphi-type techniques), who have intimate knowledge of acquisition or purchase patterns within the industry segment of concern.

SUBJECTIVE ESTIMATES



THE MARKET ESTIMATION PROCEDURE

The illustrated market estimation procedure indicates how the results of the market survey, the industrial analysis and the subjective estimates can be put together to yield a market forecast.

For each production level the number of establishments and their payback period can be obtained. The payback period allows the saturation level and cumulative chance of purchase to be obtained with the latter being a function of time (time from initial exposure to the product or service). The market to date is therefore

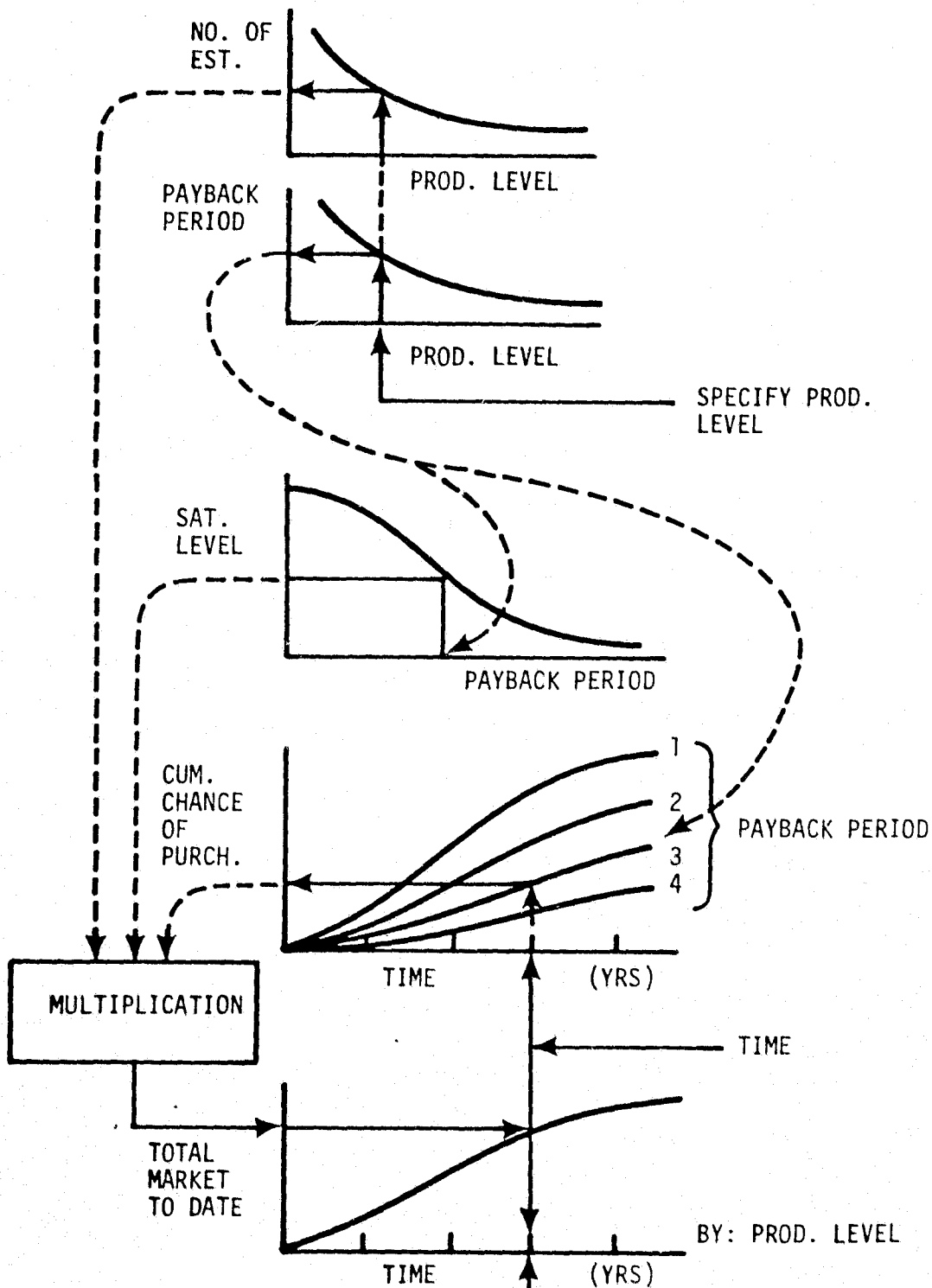
$$\text{MARKET}_{I,P} = \text{NO. OF ESTABLISHMENTS}_P \times \text{SATURATION LEVEL}_P \\ \times \text{CUMULATIVE CHANCE OF PURCHASE}_{I,P}$$

where I = time and P = production level.

As necessary, this simple model can be further complicated by allowing the number and size distributions of establishments to vary with time (there is a current trend to larger and fewer establishments), price of product or service to vary with time, or wage rates to vary with time.

It should also be noted that once user methods, procedures and operations are understood, the effect of product or service price can be ascertained by computing new payback versus production level curves and repeating the analysis using these curves. This then allows the demand function for the industry segment to be established.

THE MARKET ESTIMATION PROCEDURE



THE MARKET ESTIMATION PROCEDURE

The final step of the market estimation procedure is to sum across all production levels.

$$\text{MARKET}_I + \sum_P \text{MARKET}_{I,P}$$

This yields the total market to date (I). The annual market is therefore

$$\text{ANNUAL MARKET}_I = \text{MARKET}_I - \text{MARKET}_{I-1}$$

The sales forecast differs from the market forecast in that the market forecast indicates, as a function of time, how many units of the product or service could be sold. The sales forecast indicates how many units of the product or service will be sold, which depends on the market, the competition and the particular sales or marketing strategy undertaken.

In summary, the establishment of a market estimate requires (a) a market survey to establish general market characteristics, (b) an industrial analysis or in-depth analysis of user methods, operations and procedures, with and without the new product or service, with the objective of establishing payback period in terms of production level, and (c) subjective estimates which relate saturation level and cumulative chance of acquisition to payback period. The market estimates may be established in terms of price (the demand curve) if the analysis, in particular the industrial analysis, yields payback period versus number of establishments in terms of the price or cost of the new product or service.

THE MARKET ESTIMATION PROCEDURE

